SCIENTIFIC AMERICAN

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The problem of transportation in the city of New York is rendered extremely difficult and costly by the fact that 2,000,000 of the people live upon, and as many more daily enter or leave, a long, narrow island, which is separated from the mainland by broad and deep rivers. To overcome this isolation public and private enterprise has built, during the past decade, no less than fourteen tunnels and three of the greatest long-span bridges of the world.

BIRD'S EYE VIEW OF MANHATTAN ISLAND, SHOWING NEW YORK'S ELABORATE SYSTEM OF BRIDGES AND TUNNELS.

SCIENTIFIC AMERICAN

ESTABLISHED 1845

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NEW YORK, SATURDAY, DECEMBER 5, 1908.

The Editor is always glad to receive for examination illustrated articles on subjects of timely interest. If the photographs are *sharp*, the articles *short*, and the facts *authentic*, the contributions will receive special attention. Accepted articles will be paid for at regular space rates.

THE ETHICS OF CRITICISM.

Honest criticism is one of the most healthy tonics that can be given to an institution during the period of its development and growth; but criticism that is dishonest may work an unlimited amount of injury. We have always believed that the attack upon the designs of our battleships and upon the responsible Bureaus was prompted, at its inception, by a sincere desire on the part of some of the younger men of our navy to improve conditions in certain particulars where they believed they could be bettered; but we noted with considerable regret, that when the charges were taken up by the Bureaus, and proved to be either absolutely wrong, or true only in a limited degree, the critics and their advocates in the press began to resort to the expedient of throwing dust into the eyes of the public, by quoting those half truths, which frequently convey an impression entirely at variance with the actual facts. One leading daily journal in this city, indeed, seems to have deliberately set itself the task of so manipulating official and semi-official reports of naval proceedings, as to give the public a false impression of what has taken place.

In proof of what we have said, it will be sufficient to mention one of the most glaring instances of this persistent misleading of the public. We refer to that part of the findings of the Newport Conference (which, it will be remembered, was called by the President for the purpose of thoroughly thrashing out the whole question of battleship defects) in which, by an overwhelming majority, it was decided that in future battleships the lower edge of the armor belt should be placed twelve inches lower than it is on existing ships, and that the top edge of the belt should be placed four inches higher. Now, any schoolboy can see that the *total* effect of adding four inches above the waterline and twelve inches below the waterline is to move the whole body of the plate four inches lower with regard to the waterline than it was before. This means that it was the opinion of the Naval Conference, not that the armor belt in our existing ships was too low (which was the contention of the critics), but that, if anything, it was too high. Had they considered that the armor belt was too low, several feet too low, as the critics contend, the Conference would have added the whole increase in the width of the belt to the upper edge and raised it, not four inches, but sixteen inches higher. Yet, in spite of this obvious intention on the part of the Conference, the daily paper in question came out with a headline announcement to the effect that the Newport Conference indorsed the naval critics by deciding that the upper edge of the belt should be raised four inches higher. This is but one glaring instance out of many, of the way in which our contemporary is endeavoring to mislead the public upon a highly technical subject, in the mazes of which the average layman may only too readily become confused.

The Scientific American will probably have something more to say on this subject in a later issue; but for the present we beg to assure our readers that the findings of the Newport Conference constitute a strong indorsement of the ships of the United States navy. At the same time, it is only fair to the critics to state that the Conference approved of several valuable suggestions regarding the emplacement and protection of the battery of torpedo guns and the protection of the uptakes to the smokestacks.

SOME EARLY LIGHT-WEIGHT MOTORS.

Langley was told by steam engineers that he could not produce an engine and boiler that would weigh less than 100 pounds to the horse-power. He knew nothing about the subject of steam engineering, and was obliged to study the thing up and work it out for himself. He made many experimental engines, very tiny affairs, and eventually he produced one that, with the boiler, weighed only 7 pounds to the horse-power without water. The engine alone weighed 26 ounces, and developed 1¼ horse-power. The gasoline engines used on the models, and also on the full-sized machine, were made by Charles M. Manly. The model was air-cooled, with five cylinders, developed three horse-power, and weighed 10 pounds. The aeroplane was one-quarter the size of the man-carrying aeroplane. The engine of the latter was identical, except that it had water-cooled cylinders. The engine itself weighed 125 pounds, and with 25 pounds of water, radiator, batteries, spark coils, and all accessories, weighed just under 200 pounds. It developed 52 horse-power for ten hours continuous running at 930 revolutions per minute. The bore was 5 inches, and stroke 5½ inches. This engine was produced in 1901. There are very few motors at the present time that can equal it.

SCHOONERS FOR INTERNATIONAL YACHT RACING.

It begins to look as though future interest in international yachting would be transferred from the large single-stickers of the type of "Reliance" and "Shamrock" to the schooners. The revival of interest in this noble type is due to the success of that splendid yacht "Germania," which our esteemed contemporary, the Yachtsman, of England, designates as "the grandest schooner that ever sailed in British waters." The "Germania" is owned by a German yachtsman, and was built at the Krupp yards from plans of a German designer. During last year's racing season in the Solent, the new yacht made practically a clean sweep of all the schooners opposed to her, among which were included the best of the English yachts and the German Emperor's yacht "Meteor." The success of "Germania" naturally aroused great enthusiasm, and it has led to the placing of an order by the Emperor for the construction of a large schooner to race against the new craft next year. This, in its turn, has stimulated a leading English yachtsman to place an order for a schooner, which is to be built during the coming winter, and be ready in time for the opening gun of the yacht season of 1909. There was a time when schooner racing was the favorite sport of British yachtsmen, and we understand that every effort will be made to regain the supremacy which once was theirs. It now remains for one of our yachtsmen to build a crack racing schooner and send her to the Solent, to insure that the summer of 1909 will see some of the most brilliant and exciting international racing of the present century.

THE GRAND PRIZE AUTOMOBILE ROAD RACE AND ITS PROBABLE SUCCESSOR.

The Grand Prize race of the Automobile Club of America, which was held upon a specially-prepared 25.13-mile circuit at Savannah, Georgia, on Thanksgiving Day, was the second great international road race to be held in America this year. Against the six foreign firms that were represented by one, two, or three cars each, America had but six entries of as many different machines. Three of these machines—the Acme, Chadwick, and National—were fitted with 6-cylinder engines, while the Lozier, Simplex, and Buick had the usual 4-cylinder type of motor used upon all the foreign cars.

Twenty machines started in this 402.8-mile race, which consisted of sixteen circuits of the course. France was represented by a De Dietrich, two Clement, and two Renault cars; Germany by three Benz; and Italy by three Fiat and three Itala machines. From the start the Fiat and Benz cars led, and at the end of the tenth round the first five places were held by these two makes, the former being second and third. During the next lap a tire came off of one of the German machines and struck the driver's head, causing him to lose control and strike a tree. Fortunately neither Erle nor his mechanic was seriously injured. Nazzaro's Fiat, after leading from the twelfth round, was delayed by tire trouble in the last one, and thus lost the race to Wagner's Fiat. Hemery's Benz was second, it being beaten by but 56 seconds, and Henriot's Benz fourth. Eighth and ninth places went to Itala and Fiat cars, while Clement, Renault, and Clement machines were fifth, sixth, and seventh respectively. The French De Dietrich and American Simplex were making their fifteenth rounds and the National and Lozier their twelfth and eleventh, when the race was called off.

The time of the winner was 6 hours, 10 minutes, and 31 seconds, which corresponds to an average speed of 65.11 miles an hour. De Palma's Fiat twice covered the course in 21:36—an average speed of 70½ miles an hour. On a measured mile on one of the 3-mile straightaway stretches, several of the cars made over 100 miles an hour. Considering the number of turns in the course (thirty-seven), the average speed was even more remarkable than that of 70¼ miles an hour averaged two months ago by Nazzaro in the Florio cup race in Italy, which had only four turns per circuit. The road was oiled and in excellent condition, the seven sharp turns being well banked. The course was rigidly policed by soldiers, and there was not the crowding upon it of spectators that took place in the recent Vanderbilt cup race on Long Island. In the latter race, despite the fact that nearly half the course was formed by the cement motor parkway, an average of but 64.39 miles an hour was made by the winning Locomobile.

This recent great road race has again caused the question to be raised whether or not such races are not a thing of the past. They have served a useful purpose in developing and improving the machines; but now there is little chance for improvement in cars for touring purposes, and huge racing machines are not in favor.

In view of the flights made by the Wright brothers with their aeroplanes, and especially of the long-distance flights across country made in France by Farman and Bleriot, we believe that the Automobile Club of America should take up the subject of mechanical flight, as it has done recently in the case of motor boating; and, if possible, that it should organize a long-distance aeroplane race, to be held next summer above Long Island. Prizes of sufficient amount should be offered to attract the foreign aviators and to make it worth the while of the many American inventors now working on the problem to complete machines for the event.

By making such a move, the club would give the cause of aviation in America an impulse that is greatly needed and that it seems impossible to impart in any other way. With the Wrights to show us, we have a great advantage over the foreigners, and there is no reason why we should not at once take the lead in every respect in this new form of locomotion.

As a result of the numerous cash prizes for aeroplane flights abroad—prizes which aggregate now over $250,000—there is a very great amount of experimenting going on there at the present time, and a new industry has been created. Nurtured by the French government and by the new prizes that are constantly being offered, this industry is rapidly growing and assuming a commercial aspect. All that is needed in order to duplicate this new industry in America is the interest and support of those moneyed men who, ten years ago, gave the initial impulse here to the development of the automobile.

That a race such as we suggest would be popular can be seen from the crowds that have traveled by special trains and automobiles from Paris to Le Mans to see Wilbur Wright fly, and also from the crowd that visited Morris Park race track on Election Day to witness the exhibition of the Aeronautic Society. The American public is waiting and eager to see flying machines in action, and no more popular event could be organized than a point-to-point race of aeroplanes.

Lightning striking the earth leaves traces which vary with the character of the soil and rocks. On compact rocks it often leaves a blackish incrustation, in sand hills it produces fulgurites. These are nearly vertical channels, usually simple but sometimes branched, which are lined with vitrified silica. The outside of the tube is crumbly and usually blackened. Fulgurites are found in all countries, but most abundantly in regions of frequent thunderstorms. They are particularly abundant in some districts of the Pyrenees. The electrical origin of fulgurites has been put beyond question by the production of artificial fulgurites by the discharge of highly-charged condensers of great capacity through heaps of sand. Artificial fulgurites may also be produced by accident. In December, 1907, one of the wires of a triphase electrical circuit in Catalonia, Spain, broke a few miles from its terminus at Girone. The accident occurred at night and the passengers of a passing diligence were terrified by flames which appeared at many points of the ground. The two parts of the broken section of wire had fallen in a field of lucerne, where each part lay in contact with the ground over a length of about 45 paces. Throughout this distance and to four inches on each side of the wire the lucerne was killed. Scattered along this furrow in the vegetation were found many spongy, black, vitreous objects, resembling scoriæ. Some of these objects ended in polished balls and nearly all were hollowed out lengthwise and crumbled between the fingers. They were found most abundantly near the ends of the broken wire where some of the balls were two inches in diameter. A rough analysis of the soil showed that it was composed chiefly of sand with a little clay and limestone and traces of iron.

ENGINEERING.

It is probable that the four tunnels of the Pennsylvania Railroad Company between Manhattan and Long Island will adopt a track system consisting of treated red oak blocks, set in the concrete lining, on 20-inch centers. The blocks will be anchored to the concrete by expansion bolts; and the 100-pound rails, 60 feet in length, will be laid on 7-inch by 12-inch plates, ⅝ of an inch in thickness. The plates will be fastened to the blocks by two lag screws and the rails will be held down by clips and screw spikes.

The recent declaration of Prime Minister Asquith that in the future the British government will accept the two-power standard of naval strength as implying a preponderance by ten per cent over the two next strongest navies, has aroused no little interest in naval circles. If the "two next strongest navies" is intended to include that of the United States, which stands second in power to the British navy, the government is committed to a very large increase over its normal rate of construction, involving an additional outlay of from $25,000,000 to $30,000,000 annually.

A statement recently issued by the Pennsylvania Railroad Company shows that over $25,000,000 has been paid out by the employees' relief funds of the Pennsylvania Railroad system since their organization. Since July, 1889, on the lines west of Pittsburg, and since February, 1886, on the lines east of that city, over $15,000,000 has been paid to members who, because of illness or accidents, have been incapacitated for work. The remaining $10,250,000 has been paid to the families of members who have died.

Recognizing that the steel beams used in grillage foundations for tall buildings, because of their being concealed from examination, should be absolutely protected from corrosion, the firm of Milliken Brothers have been conducting experiments in the galvanizing of the beams after the shopwork upon them has been completed. By using the hot process in a large bath, they have succeeded in galvanizing not only I-beams, but a complete riveted-up steel column. Experimental grillages, containing galvanized steel, were broken open after they had been in the ground for six months, and the concrete was found to be in close and firm contact at every point.

The proposal to improve the efficiency of the steam-turbine propelled vessel by interposing electric generators and motors between the turbine and the propellers, is being made the target for much spirited criticism. Although it must be admitted that the higher speed of rotation which is necessary when a steam turbine drive is used causes some loss of efficiency, it has yet to be proved that the conversion of mechanical into electrical energy, and of the electrical energy back into mechanical energy, will not involve losses greater than those which it is sought to avoid.

The new Washington Street subway, Boston, which passes through the heart of the shopping district, is considered to be the most costly mile of underground railway in the world. Its construction and equipment has cost $10,000,000, or about $2,000 per lineal foot. The first section of Boston's modern system of rapid transit, consisting of subway tunnels, was opened about fourteen years ago. This was followed by the erection a few years later of the elevated road; and subsequently to that, the system was extended by the construction of the East Boston tunnel under the harbor. The opening of the Washington Street tunnel marks the latest, and one of the most important, extensions.

The next Congress will be asked to appropriate $11,341,730 for work in the navy yards during the coming year. Rear Admiral Holliday, Chief of the Bureau of Yards and Docks of the Navy, dwells, in his annual report, upon the pressing need for more drydocks, and for the construction of barracks at Philadelphia and Mare Island, capable of housing large numbers of men. The sum needed for the League Island navy yard is $721,500, and for the New York navy yard, $693,830, of which $300,000 is for work on the new granite and concrete drydock, which is to be one of the largest in the world. Admiral Holliday calls attention to the need for a drydock at Guantanamo, Cuba, to cost $2,250,000, and one at Pearl Harbor, Hawaii, to cost $2,000,000.

Speaking at the recent meeting of the Society of Naval Architects and Marine Engineers in New York city on the subject of the relation of the merchant marine to the navy, J. C. Butler, president of the Merchant Marine League, said: "To my mind, it is a disgrace to all of us that our huge battleship fleet, the pride of the nation, is convoyed and nursed around the world by a crowd of slow and shabby commercial hoboes, well named "tramps"—foreign colliers flying half a dozen foreign flags, cheaply built, with crazy hulls and rattletrap engines, and manned by the refuse of humanity. It is no wonder that these tramps have failed again and again to arrive on time, and to deliver their coal where it was expected and where it was required."

ELECTRICITY.

The use of electricity in construction work is largely increasing in this city. The current is utilized for the operation of electric hoists, pumps, and the like. The caisson work of a large new building is to be done with air compressors operated by electricity. Naturally, there is some apprehension of serious consequences, in case the current should fail while the work in the caisson is in progress, but special precautions will doubtless be taken to prevent any such accident.

A table giving statistics of single-phase electric railways in this country and in Europe has recently been prepared by the Westinghouse Electric and Manufacturing Company. According to this table, there are 28 roads (two still under construction) in America with line voltages ranging from 1,200 volts to 1,000 volts. Thirteen of the roads are equipped to use either direct-current or single-phase alternating current. The total number of locomotives used on these lines is 64. In Europe there are 34 single-phase roads using line voltages ranging from 500 to 20,000 volts, and they are equipped with 44 locomotives.

In order to determine whether electricity will convey any material particles with it when flowing through a conductor, Mr. J. Kinsky, writing in London Engineering, has made the following experiment: He took a cylinder of aluminium and placed it between two copper cylinders, subjecting the three cylinders axially to a considerable pressure. For an entire year current was passed through the series of cylinders, to see whether any particles of copper would be carried into the aluminium, or *vice versa*; 958 ampere hours were passed through the cylinders without the slightest evidence of any transfer of the metals.

Some interesting conclusions have been arrived at by the Swiss commission for studying electric operation of railways. According to this report, the maximum acceleration at starting should be 0.2 meter per second per second for express trains, 0.3 meter for passenger trains, and 0.1 meter for freight trains. The retardation should be 0.5 meter per second per second for passenger and express trains. The maximum speed of the electric train should be no greater than that now allowed, namely, 90 kilometers per hour (about 60 miles per hour) on trains with automatic brakes, and 45 kilometers per hour (about 30 miles per hour) on other trains.

An electric barometer has recently been invented, which depends for its operation upon the short-circuiting of a U-shaped carbon filament by means of a barometric mercury column. The filament dips into the top of the column, and as the atmospheric pressure increases, the mercury rises in the tube, cutting down the length of the exposed part of the filament, and thus reducing the resistance. As the mercury is also affected by temperature, a second filament and mercury column is provided. In this column the tube is sealed, so that the mercury will not be affected by atmospheric conditions. As the filament is more or less covered by the thermometric column, the resistance correspondingly varies, and this variation in resistance is introduced in the circuit of the barometric filament, so as to counteract the temperature variations in the latter.

A combined carbon-filament and mercury-vapor lamp is being introduced in Germany. The filament is inclosed in a U-shaped tube in which is a drop of mercury. The air in the tube is exhausted, and in its place an inert gas is introduced, to permit the conduction of heat from the filament to the mercury. The U-shaped tube is inclosed in a bulb similar to the ordinary incandescent electric lamp bulb. When the current is turned on, the carbon filament is immediately rendered incandescent and the mercury gradually vaporizes, increasing the light intensity to more than double the value of that of the filament. A maximum intensity is obtained in about five minutes. The lamp consumes from 1.5 to 1.6 watts per candle-power, and its life is from 600 to 1,000 hours. The light it yields is perfectly white, containing none of the blue-green rays of the ordinary mercury-vapor lamp.

The first popular application of electric heating for household use was in connection with the electric sad-iron. Now there are a large number of heating apparatus in use, which are proving very successful for occasional use or in certain special circumstances, although not in the least competing with coal for ordinary heating purposes. In a paper presented at the recent meeting of the American Institute of Electrical Engineers by Mr. W. S. Hadaway, Jr., on electric heating, he estimates that one watt will heat one square foot of common radiator surface through 1.26 deg. F. The cost of a kilowatt-hour he places at 6.7 cents, and the cost of one steam-heating unit at 40 cents. On this basis, electric heating would be fifty times as expensive as steam heating. No doubt the time will come, however, when the current which is generated from heat at the power station can be reconverted into heat at the house with sufficient economy to compete with the coal furnace.

AERONAUTICAL AND AUTOMOBILE.

The Automobile Club of France has taken up the subject of aviation and announced $40,000 in prizes for aeroplane races next year. The French government has also appropriated $20,000 for aeronautics.

On November 18 Wilbur Wright, while teaching Capt. Gerardville how to operate the aeroplane, had an accident that might have resulted as seriously as did that experienced by his brother two months before, had it not been for the celerity and coolness of the famous American aviator. In the third flight of that day, the aeroplane had been aloft for 19 minutes, when the right propeller driving chain parted, and the propeller stopped. Mr. Wright shut off the motor immediately, and glided safely to earth. It is probable that the chain had become worn through constant rubbing in the guiding tube, until one of the rivets gave way.

The Aero Club of America is soliciting subscriptions from its members for the two gold medals which were voted recently to Wilbur and Orville Wright. These medals will be worth about $1,000 each, and will be commemorative of the flights executed both here and abroad this year. As Mr. Wilbur Wright has arranged to continue his experiments for some time in the South of France, it is probable that only his brother Orville will be able to attend the banquet of the Aero Club to be given the first part of next year, when the medals will be presented. The Wright brothers have also been awarded gold medals by the Aero Clubs of both France and Great Britain.

Dr. Alexander Graham Bell's Aerial Experiment Association is busily engaged conducting a test of Dr. Bell's tetrahedral-cell aeroplane, which he has constructed at his summer home near Baddeck, C. B. A year ago the late Lieut. Selfridge made a successful ascent in the former aeroplane of this type, which had 3,392 tetrahedral cells. The present aeroplane has 5,000 cells and a spread of 42.65 feet at the top and of 32.8 feet at the bottom. Its height is 9.34 feet, and its fore-and-aft length at the bottom is the same. There is an open space about 6 feet square in the center for the aviator and the motor. The machine will first be tested by towing as a kite above the Bras d'Or Lake by means of two powerful racing motor boats. The association is also experimenting at Hammondsport, N. Y., with a new aeroplane mounted upon two light canoes. It is believed that it will be possible to attain sufficient speed to rise from the water, which would be required of an aeroplane for naval use.

Two attempts have been made recently to beat the record for long-distance ballooning, but neither of them was successful. On the 15th ultimo a transcontinental race was to start from Los Angeles, but on account of adverse winds only one balloon, the "America," ascended. This came down a few hours later on the coast some miles south of Los Angeles, after having gone out a considerable distance over the ocean. The second balloon, the "United States," started the next day, and remained up one night in a vain attempt to get over the mountains. A descent was made the following day at Corona. On November 23 the "United States" ascended at 10 A. M., and succeeded in crossing the mountains and traveling a distance of 312 miles to within 15 miles of Ehrenburg, Arizona. The balloon passed high above San Jacinto Peak, which is a mountain more than 11,000 feet high. The trip was made at a speed of more than 50 miles an hour, and by it Capt. Mueller demonstrated that a transcontinental trip is a possibility. The second attempt at beating the long-distance record was made by the huge balloon owned by the London Daily Graphic. Carrying three men, this aerostat ascended from London on November 17, and descended in a gale near Novoalexanderovsk, Russia, the evening of the following day, after having traveled a distance of about 1,150 miles. The long-distance record of Count De la Vaulx (1,193 miles), therefore, was not broken.

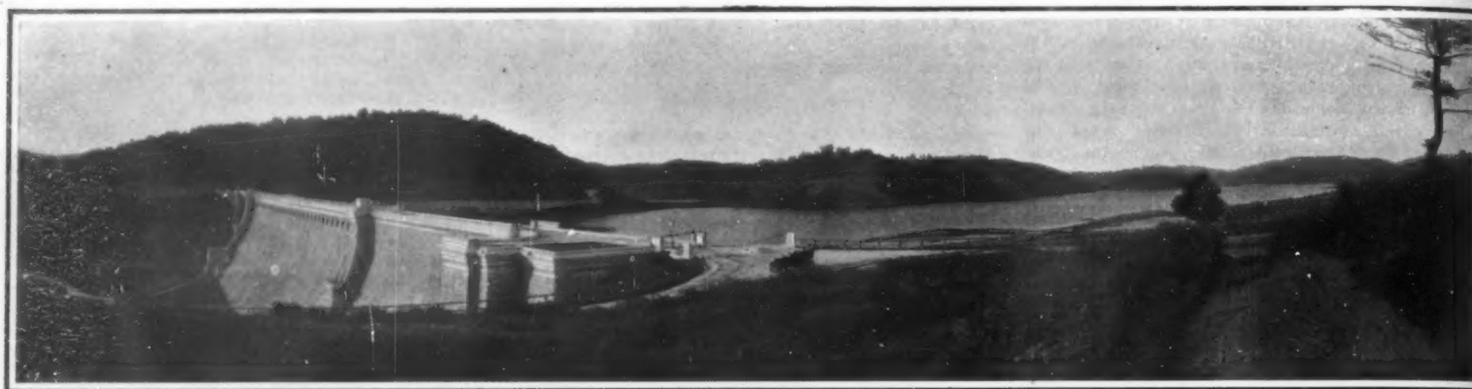
The day before the Grand Prize race of the Automobile Club of America, at Savannah, a 198-mile race for small cars was run successfully. This race consisted of twenty circuits of a 9.8-mile course. There were 12 American cars, consisting of 1 Cameron, 3 Chalmers, 4 Maxwells, and 4 Buicks, while the Italians were represented by a Lancia and Isotta, and the French by an S. P. O. The S. P. O. dropped out of the race after completing four rounds, but the Italian machines ran fast and consistently, the Lancia finally winning in 3 hours, 43 minutes, and 33 seconds, an average rate of 52.6 miles an hour. Burman, in a Buick, was second some six minutes later, and a Chalmers-Detroit, driven by L. B. Lorimer, was third. A second Buick took fourth place, and Poole, on the Isotta, secured fifth. Two 2-cylinder Maxwells were six and seventh. Two other Maxwell runabouts were running in the eighth and ninth places when the race was called off. This race demonstrated very thoroughly the speed capabilities of the small car. It is remarkable that machines of one-fourth the power of the huge racers were able to maintain a speed but 12 miles an hour less than that maintained by the latter in a long-distance race.

WATER SUPPLY

DEVELOPMENT OF THE CROTON WATERSHED.

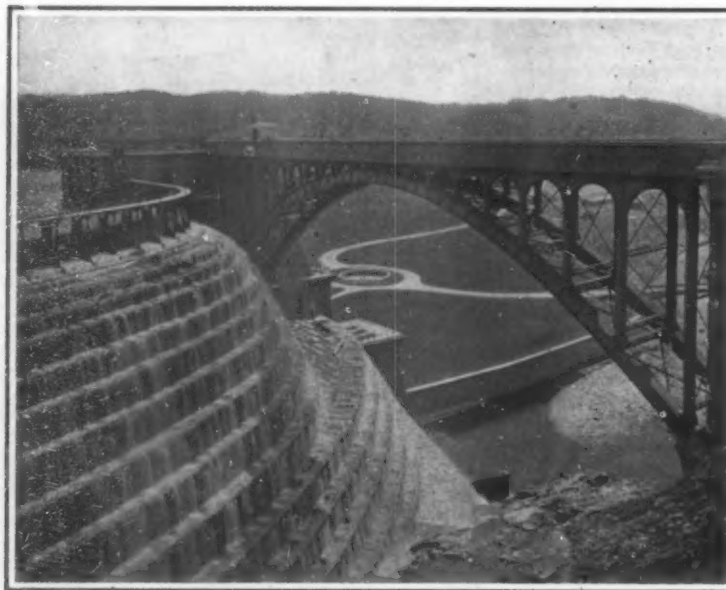
It was not until the middle of the last century that New York city undertook the construction of a system of water supply on a scale of any magnitude. After an investigation of the available watersheds, it was decided to develop a system of reservoirs in the valley of the Croton River, which flows into the Hudson from the east at a point about 35 miles distant from the City Hall. A dam 50 feet in height was built across the Croton River at a distance of about four and a half miles from its mouth, and the fresh-water lake about four miles in length thus formed, provided a supply of about two billion gallons of water. From the lake an aqueduct 8 feet 5½ inches high by 7 feet 5 inches wide and 38 miles long was built to carry the water to the city, where it was delivered to a distributing basin known as the Murray Hill reservoir, located on Fifth Avenue, between 40th and 42d Streets, which had a capacity of 24 million gallons. This work included the construction of a noble aqueduct across the Harlem River at Highbridge, which forms one of the most interesting engineering monuments in this city to-day. In its 1,450 feet of length are fifteen 80-foot and seven 50-foot arches, the under side of which is 100 feet above tide level. The new works were formally opened June 27, 1842. At that time the population of the city was only 350,000, and the consumption was 12 million gallons a day. As the aqueduct had a capacity of 90 million gallons, it must have looked to the good citizens of those days as though provision had been made for a future far removed. New York city, however, grew apace; and to meet the increased demands new reservoirs were built from time to time farther up the valley of the Croton and its tributaries. Before another half century had passed the water consumption had increased to a point where the authorities were confronted with the necessity for constructing another aqueduct. It was decided to build the new conduit of such a size that in conjunction with the old aqueduct it would be capable of delivering an amount of water about equal to the annual average daily flow of the Croton River. The New Aqueduct, as it was henceforth to be known, is built of brick. It is of a horseshoe section, measures 13 feet 6 inches in height by 13 feet 3 inches in width, and it is capable of delivering 300 million gallons of water daily. It was opened in June, 1890.

At this stage of development of the water supply the capacity of the aqueduct was, of course, greatly in excess of the capacity of the reservoirs in the Croton watershed; although these were continually increased in number to meet the growing demands of the city. About twenty years ago, however, it was realized that a large addition must be made to the existing reservoirs to meet the growth of population,

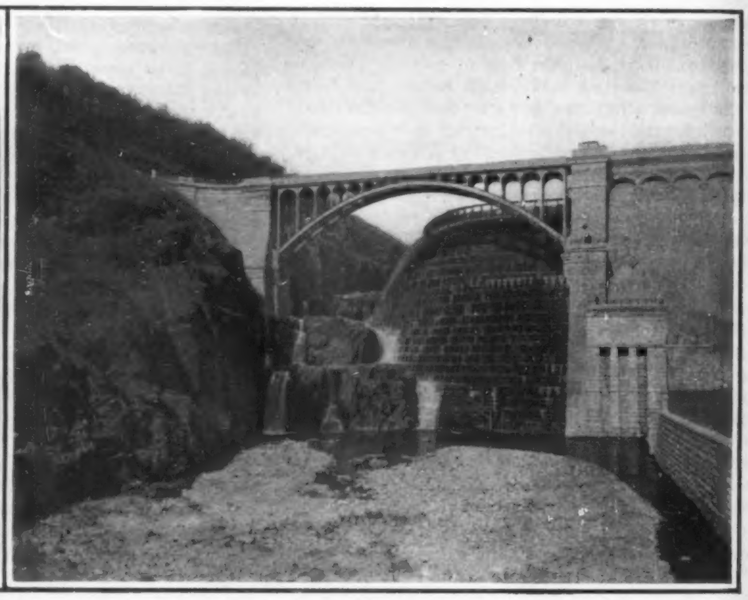


The line of the 1,000-foot spillway is seen on the far side of the lake. This panorama was taken with a Cirkut camera.

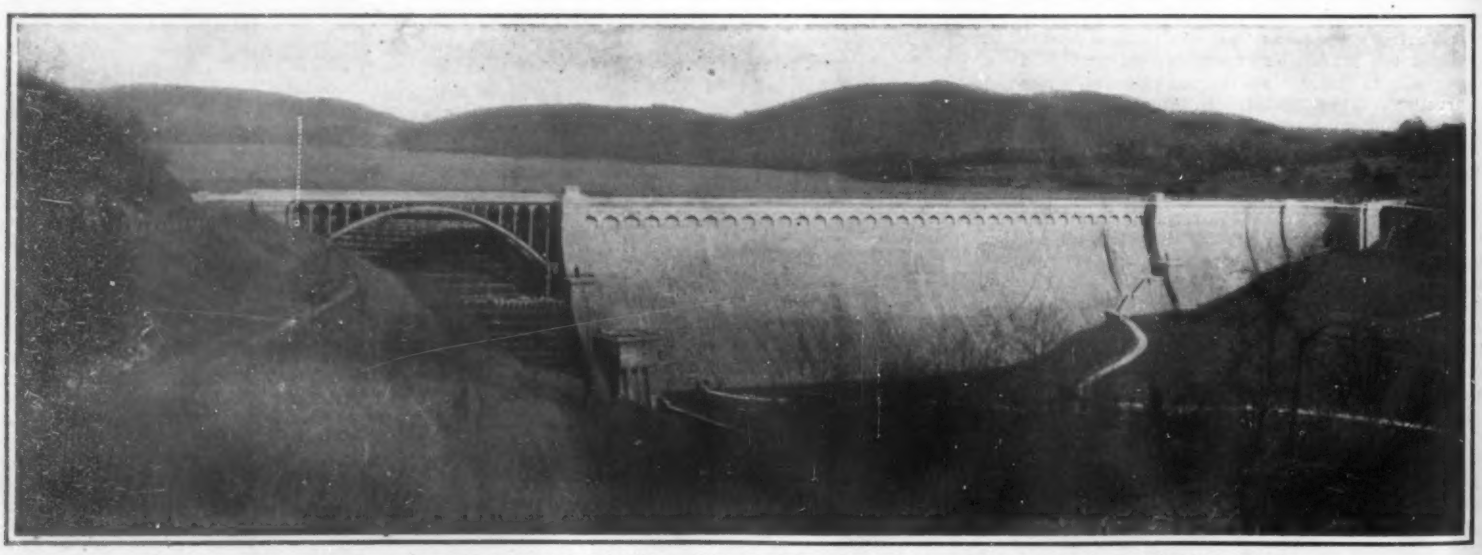
CROTON RESERVOIR FROM THE HILLS TO THE SOUTH OF THE DAM.



VIEW LOOKING DOWN THE VALLEY FROM THE SPILLWAY.



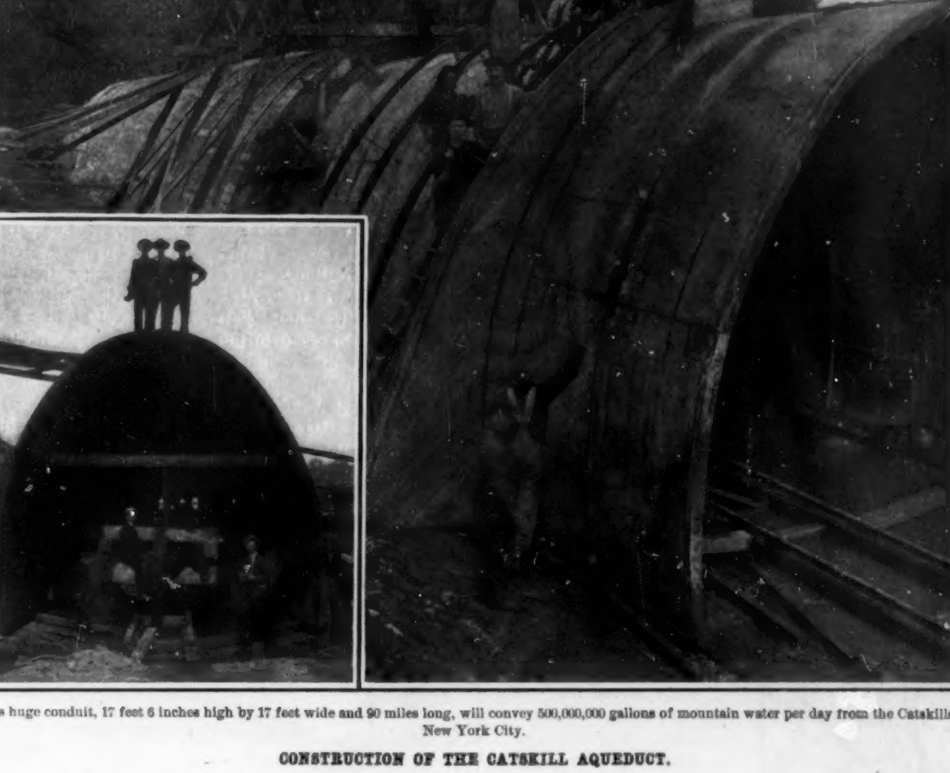
LOOKING UP THE SPILLWAY FROM THE NEW BED OF CROTON RIVER, BELOW THE DAM.



Width at base, 216 feet. Depth of base below bottom of reservoir, 140 feet. Height from bottom of foundation to crest, 297 feet. Water impounded, 30,000,000,000 gallons.

VIEW OF THE CROTON DAM AND LAKE FROM DOWNSTREAM.

which was advancing at a rapidly increasing rate. After a thorough investigation of the problem, it was decided to build an enormous dam of unprecedented height across the lower Croton valley, at a point about two miles from the mouth of the river, and create a large artificial lake about 20 miles in length, capable of impounding 30 billion gallons of water. Ground was broken in 1902, and after thirteen years of work, in which several years' delay was caused by a revision of the plans when the dam was partially completed, this great structure was opened (or, to speak more strictly, the gates were closed) and the dam began to fill on January 28, 1905.



This huge conduit, 17 feet 6 inches high by 17 feet wide and 90 miles long, will convey 500,000,000 gallons of mountain water per day from the Catskills to New York City.

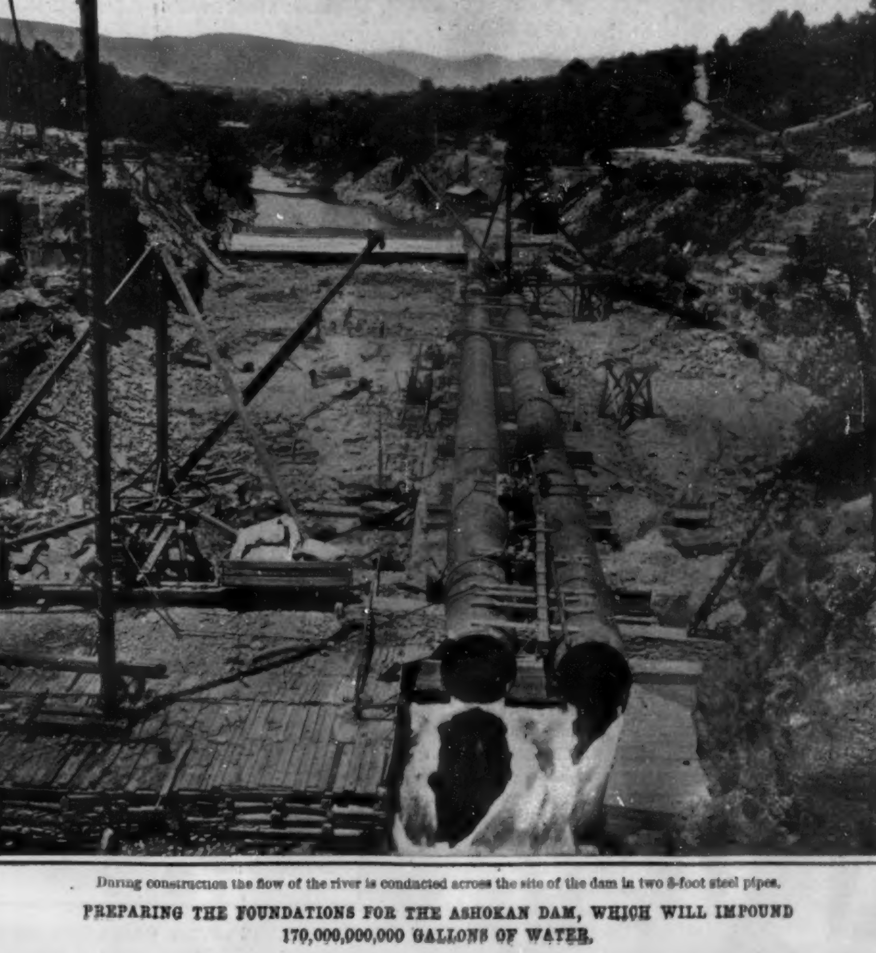
CONSTRUCTION OF THE CATSKILL AQUEDUCT.

The construction of the dam necessitated an enormous amount of excavation before rock bottom of a sufficiently solid character to support a structure of this size, and preclude the possibility of seepage below the dam, could be found. A huge trench was dug across the valley and carried down to a maximum depth of 131 feet below the original bed of the river, the width of the trench at the lowest point being about 250 feet. The work of excavating was commenced in 1892 and completed in 1896, and during this period 1,175,000 cubic yards of material was taken out. The dam as originally designed consisted of three portions. The first 400 feet on the southern side of the valley was to be an earth dam with a masonry core wall; then was to follow 650 feet of masonry which was to be continued upstream parallel with the side of the valley to form 1,000 feet of spillway. Subsequently, when the dam was approaching completion, it was decided to substitute solid masonry for the earth-and-core-wall section, and make the dam a homogeneous structure of masonry throughout its whole length. As finally constructed and shown in the accompanying engravings, the dam proper extends across the valley for a distance measured on its crest of 1,168 feet, until it is within about 200 feet of the southern side of the valley. Here it swings around and is continued up the valley for a further distance of 1,000 feet; finally turning in to a junction with the native rock of the hillside.

It is when we come to examine the cross section of the dam that its colossal proportions are manifest. Its foundations, at the widest part, are 216 feet in width, and the height from the foundation rock to crest is just under 100 yards, or, to be exact, 297 feet. The upstream face has a slight batter. The downstream face curves upwardly from the bottom width of 216 feet to a width at the top of 18 feet. The lowest point of the foundation is 131 feet below the bed of the river, and the top of the dam is 166 feet above the river bed. When the dam is full the depth of the water at the upstream face of the dam is 160 feet. The gap between the masonry dam proper and the side of the valley, forming the spillway channel discharge, is spanned by a handsome steel arch bridge, which serves to carry one branch of the system of roads which has been built around the reservoir, an important link in which is the driveway which extends across the valley along the crest of the dam. The overflow from the reservoir flows into a channel which has been blasted out between the masonry of the spillway and the rock of the hillside, and is conducted down to the old bed of the river below the dam over a series of roughly hewn steps in the rock, the water falling in a great cascade, 140 feet in height and issuing into the lower valley beneath the steel arch above referred to.

At the point in the main dam where it begins to curve into the spillway is located a gate house, in which are three 48-inch pipes controlled by gates which, during the construction of the dam, were left open to permit the Croton River to flow through, and in future will be used to draw off the waters of the dam for purposes of inspection and cleaning.

It will readily be understood that the work of building the enormous mass of masonry represented by this mammoth structure was a slow and costly work. An excellent quality of rock was found a few miles up the valley, from which the quarried rock was brought down on cars and delivered along the whole site of the dam either by overhead cableways or by means of derricks distributed in large numbers over the whole face of the work. The greater part of the dam was built of large rock weighing up to five tons apiece, the interstices between which were filled in with smaller rock and cement laid by hand. The southerly end of the dam, which replaced the earthen core-wall dam first proposed, was built by a new method, in which the large masses of rock are dropped into a bed of liquid concrete, the concrete taking the place of the hand-laid smaller rock as used in constructing the earlier portion of the dam. The total amount of masonry in the finished dam is 850,000 cubic yards; and as the preliminary excavation of the trench involved taking out 750,000 cubic yards of earth and 425,000 cubic yards of rock, the magnitude of the work will be appreciated. As the masonry rose in the trench, the better quality of earth which had been excavated was brought back and filled in against the dam on both upstream and downstream faces, the downstream side being finished off in broad, easy slopes, and an attempt at landscape gardening being made by the erection of a fountain and the construction of winding roads. This last work, however, is somewhat crude, and it is to be hoped that at some future day the city will take this matter in hand, smooth down the unsightly banks of excavated material, plant the hillsides with trees and shrubbery, and render the approach to this truly magnificent structure worthy of its dignity and importance.



During construction the flow of the river is conducted across the site of the dam in two 8-foot steel pipes.

PREPARING THE FOUNDATIONS FOR THE ASHOKAN DAM, WHICH WILL IMPOUND 170,000,000,000 GALLONS OF WATER.

At high water level the crest of the old Croton dam, built in 1843, is buried 30 feet deep by the reservoir formed by the new dam; and at this point is located the principal gate house through which the water is led into the old and the new aqueducts. The creation of a lake that backs 20 miles up the Croton Valley

necessitated an entire relocation of the systems of roads and the construction of a large number of costly bridges to carry these roads over various arms of the lake. These crossings include a 124½-foot bridge; two spans of 217 feet; one of 310 feet, one of 396 feet, and

MAP OF CATSKILL AND CROTON WATERSHEDS, SHOWING THE NEW CATSKILL AQUEDUCT.

a handsome cantilever structure with a central span of 384 feet. The system of new roads extends for 50 miles around the lake. These supplemental works, together with the cost of the real estate, etc., brought the total cost of the whole scheme up to a round sum of about $12,000,000.

During the construction of the new Croton dam the city undertook the building of the Jerome Park reservoir, lying near the northerly limits of New York city, which is designed to act as a storage and distributing reservoir within the city limits. The reservoir as designed has an area of 239 acres and a depth of 26½ feet. The excavation involved the taking out of about 11 million cubic yards of material, most of it rock. It is divided by a wall that runs through it in a north and south direction; and the easterly half, which has been completed and entirely lined of concrete, has a maximum full capacity of 773,400,000 gallons.

Subsequently to the completion of the Croton dam a large reservoir known as Cross River, holding 10,308 million gallons, has been completed, and another, the Croton Falls reservoir, with a capacity of over 14 billion gallons, is under construction. When the last-named is completed there will be ten separate dams in the Croton watershed, with an aggregate capacity of 104,530 million gallons.

During last winter, from November 6 to March 15, all the reservoirs on the watershed were full and overflowing, and during this period over 80 billion gallons of water ran to waste over the spillway of the new Croton dam. With a view to storing a portion of such waters as would overflow in the future, it is proposed to build one more dam in the upper reaches of the watershed, which will have a capacity of 20 billion gallons and will be known as the Patterson reservoir.

From what has been said it will be seen that the limit of the storage capacity of the Croton watershed has about been reached. The daily average flow of the Croton River during the past forty years has been 402,320,000 gallons. The present daily consumption of water in New York city is about 325,000,000 gallons. Taking into consideration the increasing rate of growth of population of the city, and the fact that the annual increase in water consumption is at present at the rate of 15 million gallons daily per year, it can be seen that within a few years' time the consumption of the city will have exceeded the daily river flow and the capacity of 380 million gallons of the two aqueducts leading from Croton reservoir to New York. As the result of an exhaustive examination by various boards of engineers, it was found that the nearest available source for a new water supply was to be found in the region of the Catskill Mountains; and a gigantic scheme has been approved and is now being carried through for bringing a supply of fresh mountain water into New York city from the Catskills, to the extent of 500 million gallons daily, at a total cost of $161,000,000.

THE CATSKILL WATER SUPPLY.

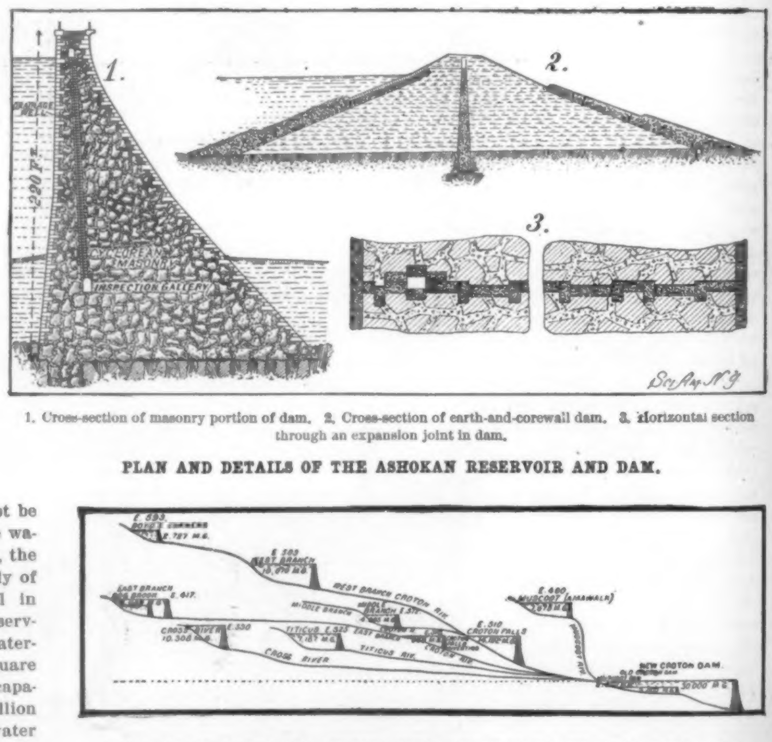
In selecting a new source of water supply the engineers of the board realized that the conditions surrounding New York city were unusually perplexing. To the east the city is shut in by the Atlantic Ocean and to the west it is excluded by the laws of New Jersey from tapping any of the water sources of the State. A most excellent supply might have been drawn from the sources of the Housatonic River, had the district not been excluded from consideration because of its location in the State of Connecticut. Hence, the city has been driven by its geographical and legal restrictions to go far afield in its search, even to the regions of the Catskill Mountains. The disadvantages of distance, however, are compensated by the fact that the watersheds are sparsely inhabited, and that the water supply is not only abundant but is of excellent quality. By reference to the accompanying map, it will be seen that when the whole scheme has been developed water will be taken from four separate districts. The first of these, the Esopus Creek watershed, has an area of 255 square miles. Its waters will be impounded by the construction of a huge dam 220 feet in maximum height and 5,650 feet in length, which will be built across the valley of the Esopus at what is known as the Olive Bridge site. The dam will create what will be known as the Ashokan reservoir, which will be 2½ miles in width, with a full level capacity of 170 billion gallons, and will be capable of supplying the city with 250 million gallons of water a day.

The rate of growth of Greater New York is so rapid that it cannot be many decades before the watersheds of the Rondout, the Schoharie, and ultimately of the Catskill rivers will in turn be brought into service. The Rondout watershed covers 176 square miles, and would be capable of yielding 130 million gallons daily. This water will be stored in what will be known as the Napanoch reservoir, from which its waters will be led by an aqueduct into the main Catskill aqueduct a couple of miles below the Ashokan reservoir. Later, the Schoharie watershed will be brought into service by the construction of the Prattsville reservoir, its waters being brought into Esopus Creek by means of a tunnel through the divide. Lastly, the Catskill water will be impounded in several reservoirs located along that stream, and brought into the Ashokan reservoir by an aqueduct whose location is shown on the accompanying map. Altogether, when the whole scheme is completed, New York city will have at command over 700 million gallons daily water supply from the Catskill Mountain watershed in addition to the 375 million gallons daily already available in the Croton watershed.

The Ashokan dam, like the Croton dam above described, will take rank as one of the greatest structures of its kind in existence. It will be built partly of solid masonry and partly of earth. The masonry portion, which will extend for about 1,000 feet and occupy the center of the dam, will be built of the general cross section shown in the accompanying engraving. The width of the base will, of course, vary with the depth of the foundations; but at the center it will be not far from 200 feet. Its height taken at the same point will be 220 feet. The earth-and-core-wall portions of the dam will extend from the masonry middle section to a junction with the valley on one side, and some high ground on the other. The total length of the dam will be 5,650 feet. In addition to the dam there will be a series of dikes which will be built across depressions in the country and serve to hold the water at the desired level. Beyond the dikes will be a large waste weir. The dikes will constitute a very important work, for together with the waste weir they will have a total length of 3.8 miles. One of our illustrations shows the preliminary excavation work for the dam and the means adopted for by-passing the flow of the Esopus Creek during construction, which is being done by means of two 8-foot steel pipes which will be sufficient to accommodate the creek at its ordinary level. Subsequently, as the excavation is carried further down, the water will be diverted through a channel formed along the side of the valley. Ultimately, during the erection of the masonry of the dam, the water will flow through a tunnel, which will be left open for that purpose and closed when the dam is completed.

From the dam the water will flow by gravity through a huge steel-and-concrete aqueduct 17 feet in the clear

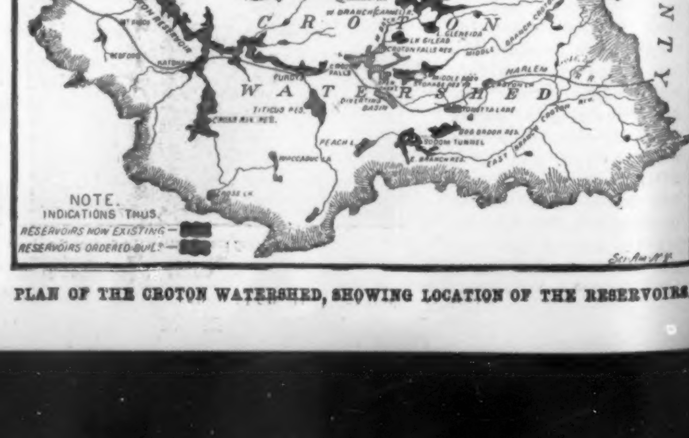
(*Continued on page 414.*)



1. Cross-section of masonry portion of dam. 2. Cross-section of earth-and-corewall dam. 3. Horizontal section through an expansion joint in dam.

PLAN AND DETAILS OF THE ASHOKAN RESERVOIR AND DAM.

DIAGRAM SHOWING ELEVATION AND CAPACITY OF CROTON RESERVOIRS.



PLAN OF THE CROTON WATERSHED, SHOWING LOCATION OF THE RESERVOIRS.

THE CITY'S GIANT BRIDGES

Although the famous Brooklyn suspension bridge was built a quarter of a century ago, and, therefore, cannot legitimately be included in a review of the engineering work of the past decade, we have given it a place among our illustrations, first because of its great historical interest, and secondly because it forms such an important member of the quartette of giant bridges which span the broad waters of the East River, and afford the principal means of communication between New York and Brooklyn.

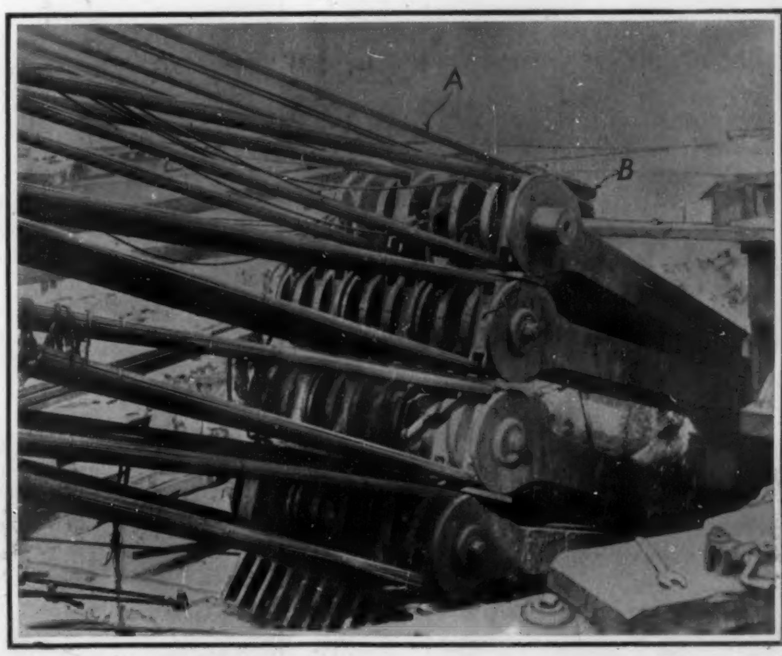
The wire suspension bridge is essentially an American production; for although chain suspension bridges, in which the main supporting members consisted of flat iron bars linked together by pins, had been built in some numbers in England and on the Continent, the use of wire cables is one of the original and distinguishing characteristics of American long-span bridges. When Col. Roebling first promulgated his plans for spanning the broad expanse of the East River with a wire cable suspension bridge of the enormous span of 1,595 feet, the scheme was regarded with no little apprehension. The longest existing bridges were of less than 1,000 feet span; and it was considered that there were insufficient reliable data available to guarantee an advance to proportions of the unusual magnitude proposed. Great honor, therefore, is due to Mr. Roebling for the courage with which he staked his reputation upon the venture, and the indomitable pluck with which he and his associates carried it through to successful completion. The foundations for the towers were prepared by sinking two huge timber caissons to the rock underlying the river mud and sand. Upon these were erected two massive masonry towers which were carried up to an extreme height of 272 feet above the river. Meanwhile the anchorages, consisting each of a mass of solid masonry, were constructed on either shore, at a distance of 930 feet from the towers, and deep within this masonry were imbedded the huge anchor plates and anchor bars to which the wire cables were attached. Originally it was planned to make these cables of iron wire; but by the time the bridge was ready for their erection, the advance in the manufacture of steel had been such that it was found possible to use steel in place of iron, and thus secure much stronger cables without any increase of weight. It is to the wisdom shown in the adoption of this stronger material that the city is indebted for the ability shown by the bridge, in the later years of its life, to carry loads greatly in excess of those for which it was originally designed. There is no foundation for the popular belief that the bridge is to-day "greatly overloaded." As a matter of fact, the steel wire cables are perfectly well able to carry their present burden. The so-called weakness of the bridge is due to the comparative weakness of the floor system, and particularly of the stiffening trusses, which on several occasions have been buckled or broken. Of late years, however, the bridge has been subjected to careful and continued scrutiny by competent engineers; and, so long as this is done, no fears need be entertained for the safety of the structure. Plans have been prepared by the Bridge Department, moreover, for the reconstruction and stiffening of the bridge, which include the erection of deeper and stronger stiffening trusses and a complete rebuilding of the floor system. This work will be undertaken as soon as the adjoining Manhattan Bridge has been completed, and when it is completed, the bridge will be good for many centuries of useful service, and will last just as long as it is safeguarded against rusting and decay by frequent painting and careful all-round maintenance.

THE WILLIAMSBURG SUSPENSION BRIDGE.

In the closing years of the last century the city undertook the construction of another wire cable suspension bridge. The location of the crossing was laid from Delancey Street, Manhattan, to Broadway, in Brooklyn. The main span is slightly longer than that of the Brooklyn Bridge, the clear width from tower to tower being 1,600 feet. The shore spans, however, are only 596½ feet, as against 930 feet, which is the length of the shore spans of the older structure. In point of weight and carrying capacity, the Williamsburg Bridge, as it is called, is a vastly greater structure; for whereas the floor of the Brooklyn Bridge is only 80 feet wide, with provision for two elevated tracks, two trolley tracks, two 18-foot roadways with two trolley tracks upon them, and a footwalk, the Williamsburg Bridge is 120 feet wide and carries two elevated tracks, four trolley tracks, two 18-foot passenger footwalks between the trusses and two 20-foot roadways on the outside of the trusses, carried on cantilever extensions of the floor beams. The lack of stiffness of the floor of the Brooklyn Bridge is due to the light construction and shallow depth of the trusses, two of which are 8 feet 9 inches and four 17 feet in depth. This was remedied in the Williamsburg Bridge by the provision of two unusually heavy trusses, each 40 feet in depth, extending continuously from anchorage to anchorage. The steel towers are erected upon heavy masonry piers beneath which are huge caissons which were sunk to the underlying bedrock. The steel towers are carried to a total height of 335 feet above the river. The four cables, each of which is 18¾ inches in diameter, are connected at their ends to heavy cast steel shoes which are pinned to a series of steel anchorage eye-bars imbedded in the masonry of the anchorages. The steel used in constructing these cables is of unusually high tensile strength, the best specimens showing a breaking strength, in some cases, as high as 210,000 pounds to the square inch. The cables for supporting the roadway are attached to the main cables by means of heavy cast-iron saddles, and at their lower ends they are looped around cast-steel shoes, from which the floor beams of the bridge are hung by four heavy steel bolts. It will be noticed from our illustration that there are no suspender cables for the shore spans of the bridge, the main cables serving to carry the weight of the central 1,600-foot spans only. The shore spans consist of extensions of the stiffening trusses; and the load of each of these spans is carried by the tower, the anchorage, and a steel pier located at the center of the truss. The total cost of the bridge, including the approaches and purchase of real estate, was about $22,000,000.

This view shows the cables in course of construction. One end of the wire from a reel is passed around the sheave shown near left-hand corner of engraving, which is drawn across the bridge, thus stringing two lengths of wire at each journey.

ONE OF THE MANHATTAN BRIDGE ANCHORAGES.



Each cable consists of 37 strands in each of which is 250 wires.

THE CONNECTION OF THE WIRE STRANDS TO THE ANCHOR BARS.

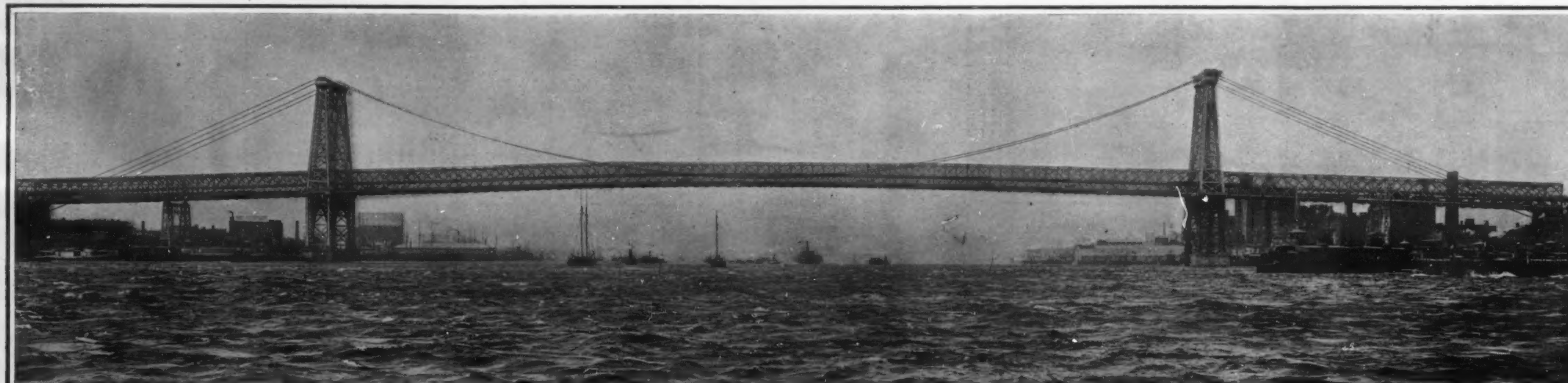
THE MANHATTAN SUSPENSION BRIDGE.

The third of the great crossings of the East River, known as the Manhattan Bridge, which is located about a quarter of a mile to the east of the old Brooklyn Bridge, is now in process of erection, and will probably be opened in 1909-10. Originally designed as a stiffened chain-cable bridge, the plans were subsequently changed by the substitution of wire for chain cables. Upon its completion the bridge, in respect of its carrying capacity, will be the largest suspension bridge in existence, provision having been made for eight railroad and surface tracks, a 35-foot roadway, and two passenger footwalks, each 11 feet in width.

No small part of the cost of building a bridge of this character is due to the difficult nature of the foundations. The caissons for the Williamsburg Bridge were four in number, there being two for each tower; an arrangement which was necessitated by the rather steep slope of the underlying rock at the site of the towers on each side of the river. The borings for the Manhattan Bridge piers showed the surface of the underlying rock to be fairly level, and hence it was decided to construct a single huge caisson for the foundations of each tower. The dimensions of the caissons were necessarily large. They measured 78 feet in the direction of the axis of the bridge by 144 feet transversely to the axis. The caisson proper on the Brooklyn side was 55 feet 6 inches in depth and above this was built a temporary cofferdam, which was erected to prevent the water from flowing into the work during the process of sinking. The total depth of this huge box, when it finally reached bedrock, was about 100 feet. The walls of the caisson were built of two layers of 12 x 12-inch timbers, the outer one laid horizontally, and the inner vertically; while on the outside of this was a double layer of 2-inch planking, the inner one laid diagonally, and the other vertically. Six feet from the bottom cutting edge, which was shod with steel, there was built over the whole caisson a solid roof of timber 2 feet 9 inches in thickness stiffened by heavy trusses. The space beneath this watertight roof, known as the working chamber, was divided into three longitudinal sections, and in this chamber the excavation was done by a large army of "ground hogs," as the men who perform the work of excavation are called. From the working chamber there extended to the surface of the cofferdam nine steel shafts for material, and one elevator shaft. The material at the river bottom was found to be almost pure sand; and it proved possible to blow out the excavated material by means of compressed air which was forced into the working caisson for the workmen. This was done by means of fourteen 4-inch wrought-iron pipes, which extended from the roof of the working chamber to the surface. At the bottom of each of the 4-inch pipes was a length of hose, which reached from the roof of

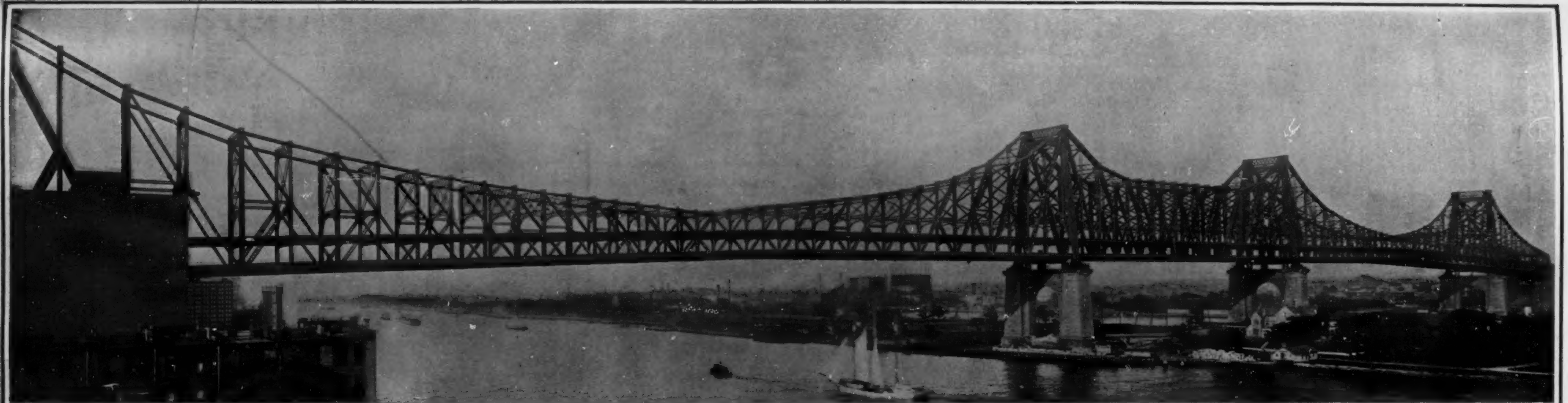
Length of main span, 1,595½ feet; side spans, 930 feet. Total length, including approaches, 6,016 feet. Width of bridge, 85 feet. Height of towers, 272 feet above the water. Diameter of cables, 15¾ inches. Capacity: Two rapid transit tracks; two surface tracks on two 18-foot roadways; one 15-foot footwalk. Total cost, $16,000,000.

BROOKLYN BRIDGE. CONSTRUCTION COMMENCED 1870. OPENED 1883.



Length of main span, 1,600 feet. Side spans, 596½ feet. Total length, including approaches, 7,279 feet. Width, 114 feet. Height of towers above high water, 335 feet. Diameter of cables, 18¾ inches. Capacity: Two rapid transit tracks; four surface tracks; two 20-foot roadways; two 17½-foot footwalks. Total cost, $22,000,000.

WILLIAMSBURG BRIDGE. CONSTRUCTION COMMENCED 1896. OPENED 1903.



Two channel spans, 1,182 feet and 984 feet; one island span, 630 feet; two anchor spans, 469½ feet and 459 feet. Total length, including approaches, 8,600 feet. Maximum depth of trusses, 185 feet. Width of bridge, 88 feet. Capacity as planned: Four rapid transit tracks; four surface tracks; one 84-foot roadway; two 14-foot footwalks. Because this bridge is overstressed it is under consideration to remove all or part of the rapid transit tracks. Cost $20,000,000.

QUEENSBOROUGH (BLACKWELL'S ISLAND) BRIDGE. CONSTRUCTION BEGUN 1901. TO BE OPENED 1909.

Length of main span, 1,470 feet. Side spans, 725 feet. Total length, including approaches, 6,855 feet. Width, 120 feet. Height of towers above high water, 322 feet. Diameter of cables, 21¼ inches. Capacity: Four rapid transit tracks; four surface tracks; one 35-foot roadway; two 11-foot footwalks. Total cost, $26,000,000.

MANHATTAN BRIDGE. CONSTRUCTION COMMENCED 1901. TO BE OPENED 1909-1910.

the working chamber to the bottom of the excavation. A 4-inch water pipe also passed through the caissons, and supplied water at 100 pounds pressure to six jets. One of these jets was directed at the sand around the bottom of each blow-pipe, and served to loosen it so thoroughly that the air pressure in the caisson proved sufficient to blow the sand up through the pipe and out over the edge of the caisson. When the caisson reached solid rock, the whole interior of the working chamber was filled in with tightly rammed concrete, the interior of the caissons above the roof being also filled with the same material, thus providing a solid concrete and timber mass from the rock below the bed of the river to the top of the caisson, which stands at a level of 37 feet below mean high water. Above the caissons was built a solid masonry pier whose coping is 23 feet above mean high water, the total depth from coping to the caissons being 60 feet. The construction of the foundation and piers on the Manhattan side was practically identical, the only difference in dimensions being that due to the difference in depth to rock bottom.

Upon the top of each of the masonry piers were built four massive steel footings, and upon these were erected the plate-steel legs or columns of the steel towers. Each tower consists of four apparently slender but actually exceedingly heavy and stiff columns that rise 322 feet above the water level. Each pair of columns is braced together by a truss system, which extends continuously from base to top, except where it is omitted in two panels to provide for the passage of the lines of railway track. Each pair of columns, as thus connected, is braced together by transverse trusses, one below the floor of the bridge, another at the level of the upper deck and a third at the top of the tower.

In previous suspension bridges it was customary to cradle the main cables, but in the Manhattan Bridge the cables lie in the same vertical planes as the respective legs of the towers over which they pass. In respect of its carrying capacity, the Manhattan Bridge is the largest of the four great bridges across the East River. The suspended roadways are carried on two decks. Upon the lower deck provision is made for four surface tracks, a 35-foot roadway, and two 11-foot passenger walks; while upon the upper deck there will be four elevated railway tracks. To carry so great a load, the dimensions of the cables and anchorages are necessarily very large. The anchorages measure 175 feet in width by 225 feet in length, and the cables reach the unprecedented diameter of 21¼ inches, as compared with the diameter of 18¾ inches on the Williamsburg Bridge and 15¾ inches on the Brooklyn Bridge. The necessary stiffness will be given to the suspended roadway by four heavy riveted nickel-steel trusses, lying in the planes of the four cables and suspended from them.

For the construction of the cables four temporary cables, each consisting of four 1¾-inch diameter steel ropes, were strung from anchorage to anchorage over the towers. Upon them were laid four working platforms for the accommodation of the workmen. The stringing of the wires in each cable is accomplished by means of two traveling sheaves, carried on opposite legs of an endless steel rope reaching from anchorage to anchorage. Each sheave consists of a 3-foot grooved wheel, attached to the hauling rope by brackets. The hauling rope runs on heavy rollers supported on uprights on the temporary foot-bridges. The wire is delivered to the bridge on enormous reels weighing 3 tons each, half of them being placed on each anchorage. The end of the wire from a reel at each end of the bridge is put over the hauling sheave at that end and fastened to the anchorage, and each hauling rope is driven by a 50-horse-power, 220-volt Crocker-Wheeler form W motor. The hauling machinery is then started, and, as the sheaves move across the bridge, they unwind one wire from each reel, and two wires are thus strung by each sheave every time it makes the trip across the bridge. There are 256 wires in each strand, and as the strands are completed they are lifted from the temporary saddles in which they rest and placed in the permanent saddle. Each cable contains 37 strands of 256 wires each, so that there is a total of 9,472 wires in each cable. The total length of single wire in all four cables will be 23,100 miles. The wire has a breaking strength of 215,000 pounds to the square inch. The weight of the four cables in their completed condition will be 8,600 tons. The side spans of the bridge are 725 feet and the central span is 1,470 feet in length. When the bridge is completed the total weight of steel in the structure will be 42,000 tons.

THE QUEENSBOROUGH CANTILEVER BRIDGE.

The Queensborough cantilever bridge, formerly known as the Blackwell's Island Bridge, is the latest of the four great bridges across the East River. Commencing from the Manhattan shore, the dimensions and positions of the successive spans of the bridge are as follows: First there is an anchor span 469 feet long; then a channel span 1,182 feet long, followed by what is known as the Island span crossing Blackwell's Island, which is 630 feet long. Then comes a 984-foot span over the east channel of the river, and a 459-foot anchor span extending over the Long Island shore. The total length of the bridge, including the approaches, is 8,600 feet. The maximum depth of the trusses at the towers is 185 feet, and the extreme width of the bridge is 88 feet. As originally planned, the bridge was designed to carry a maximum congested live loading of 12,600 pounds per lineal foot, on four surface trolley tracks, two elevated railway tracks, a roadway, and two footwalks. Following a change of administration and engineers, it was decided to add two additional elevated railroad tracks on the upper deck of the structure, and a heavier congested loading was adopted of 16,000 pounds to the lineal foot. When the bridge was nearing completion, the engineering world was startled by the fall of that other great cantilever structure, the Quebec Bridge; and it was natural that considerable anxiety should be aroused regarding the Queensborough Bridge, since it was not only designed on the same general principles, but was a heavier structure in itself and was to be subjected to a heavier load than the bridge that went down. Two separate investigations of the strength of the bridge were made for the Bridge Department; and in both cases it was found that not only was the bridge over weight, but that if it were loaded according to the requirements of the specifications the stresses in some of the members would exceed the specified stresses by from 25 to 47 per cent. One of the consulting engineers recommends the taking of considerable dead load from the bridge and the removal of two of the elevated railway tracks. The other report advises the removal of all elevated tracks.

The fall of the Quebec Bridge and the conditions existing in the Queensborough Bridge cannot fail to raise a doubt in the minds of engineers as to the suitability of the cantilever system to the construction of heavily-loaded bridges of over 1,000 feet in length of span; and this, in spite of the fact that troubles in both cases were due chiefly to faulty design. The Queensborough Bridge is an enormously heavy structure, the weight of the whole mass from abutment to abutment of the cantilevers being 52,000 tons. The 630-foot span across the Island alone weighs 10,400 tons, or 16½ tons to the lineal foot. The trusses are built partly of a special nickel steel and partly of the ordinary commercial structural steel, the latter being used generally for the compression members and floor system and nickel steel for the eye-bars or tension members. In the structural steel the specifications called for an elastic limit of 28,000 pounds, and an ultimate strength of 56,000 pounds. The requirement of the nickel-steel eye-bars are an elastic limit of 48,000 pounds and an ultimate strength of 85,000 pounds, from which it will be seen that the nickel-steel bars are from 40 to 50 per cent stronger than ordinary structural bars of the same weight.

The erection of the bridge was done by the overhang method. First the anchor arms on the Manhattan and Long Island shores and the span across the island were erected on steel falsework. Then the four river arms of the cantilevers were built out by overhang to a junction in midstream by means of two massive travelers each 120 feet in height. This traveler was in itself a huge and costly affair weighing 500 tons and capable of handling a load of 70 tons. It is probable that the bridge will be opened during the year 1909. In closing our article on the long-span bridges of New York, mention should be made of the fact that the plans have been drawn for a massive 1,000-foot steel arch bridge which is to carry a four-track railroad across the East River at Hell Gate, and form part of an important link connecting tracks of the New Haven Railway with those of the Pennsylvania Railway on Long Island.

In a remarkable paper read at the meeting of the American Philosophical Society in Philadelphia, Dr. Alexis Carrel of the Rockefeller Institute showed how the kneejoint of a dead man has replaced the injured joint of a living person; how the arteries of husband and wife have been successfully joined, so that the wife might endure the shock of a surgical operation; how an infant's blood has been revitalized by the blood of its parent; how a human artery and jugular vein have been interchanged and are fulfilling each the other's function; how the kidneys of one cat were substituted for the corresponding organs of another, and how a living fox terrier now frisks about upon the leg of a dead companion. "In my experiments to preserve arteries," states Dr. Carrel, "I found that desiccation would not do, but produced a state of absolute death. Then I put the arteries in refrigerators and kept them inclosed in hermetically sealed tubes, at a temperature a little above freezing. I found that an artery could be kept alive for sixty days and substituted for the artery of a living animal." Clearly, the day is not far off when the perfect organs of a man who in life had been free from disease may be kept in cold storage after his death and used to replace diseased organs in living men.

TALL BUILDINGS OF NEW YORK

Although New York city was not the first to possess a mammoth office building of the modern "skyscraper" type, the growth of such buildings in number and size during the past few years has been so rapid as to render lower New York distinctively a city of towers. To the wonderful skyward growth of this city, several causes have contributed. Chief among these, and closely related, are the circumscribed limits of the site on which the city is built, and the high cost of the land. The high price of real estate and the restricted area of desirable sites, it is true, have served to promote the construction of lofty buildings in other cities besides New York; but nowhere have these proved such powerful and impelling motives as here. The desire on the part of large business interests to be located as closely as possible to the financial center, moreover, has helped to produce that huge pile of lofty buildings which makes lower New York, in the neighborhood of Wall Street, look from a distance as though it were a city built upon a hill. Below Chambers Street the prices of real estate will run from $30 to $40 per square foot, near the water, to $200 and $300 per square foot in the Wall Street district. The highest price ever realized was that paid for a small corner plot at the southeast corner of Wall Street and Broadway, which recently sold for $700,000 or at the rate of $600 per square foot. This is the highest price ever paid for real estate in any city of the world. It is not at all unusual for the cost of the site of a building in this city to exceed the cost of the structure itself. This was the case with the Fuller Building, popularly known as the Flatiron Building, whose triangular site cost $2,500,000. Where such vast sums are paid for the building site, it becomes necessary to add story to story until sufficient rentable floor space has been secured to guarantee a reasonable profit upon the cost both of the site and the building.

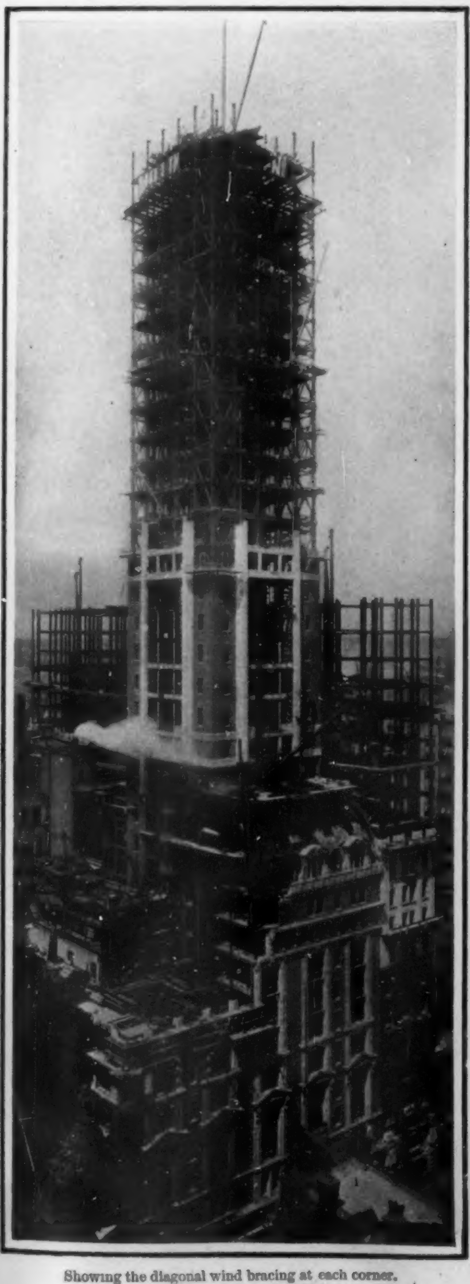
The development of the lofty office building is one of those modern engineering achievements which were rendered possible by the introduction of Bessemer steel. The limit of height for an ordinary brick or stone building of the older kind, is reached when the thickness of the lower walls becomes such as to seriously encroach on the usable floor space of the building. The tallest structures of this kind have stopped at a height of twelve to fourteen stories; this last being the height of the Singer Building, before its recent reconstruction. The walls of this structure in the lower stories are nearly three feet in thickness. With the introduction of steel columns, girders, and stringers in building construction, it became possible to transfer the loads of each story of a building directly to vertical columns, by which they were carried direct to the foundations; and the intermediate spaces between the columns required only a sufficient thickness of wall to serve the purposes of inclosure. The introduction of steel thus served the double advantage of reducing the thickness and weight of the walls and of enabling the loads to be concentrated on a specified number of vertical members, whose supporting power it was possible accurately to determine. Not only was a great reduction made in the weight, but there was a corresponding increase in the elements of safety and durability. The stresses in a tall building can be calculated with accuracy; and by introducing the proper amount of wind bracing, these structures may be made absolutely secure against being overthrown by storm, and reasonably secure against earthquake. Furthermore, the skeleton steel building is a form of construction that lends itself admirably to fireproofing; and, if the columns and beams be thoroughly protected by good terra cotta or concrete, and metal be used for the construction of doors, window sashes, frames, and, as far as possible, for the furniture, a modern office building may be rendered practically proof against fire—so far proof, indeed, that if a fire starts among the contents of an office, it will be localized for want of any combustible material upon which to seize in the building itself. The San Francisco fire proved that, where the most modern methods of fireproofing were used, a tall building could go through even such a fierce conflagration as that, and yet remain so far intact as to be capable of speedy repair. The question has often been asked, particularly since the San Francisco disaster, as to how the tall buildings in this city would be affected by earthquake shock. Judging from the results at San Francisco, they would pass through an earthquake with surprisingly little damage. This is explained by the fact that the shock is taken care of by the elastic properties of the steel frame; and where the walls and panel work have been attached to the frame by the most approved methods, the worst that can happen is a slight cracking of the masonry.

The steady increase in height of tall buildings has raised the question in the minds of many people as to

how high it would be possible to go in safety. In an investigation of the problem made by Mr. O. F. Semsch, who was responsible for the design of the steel work of the Singer tower, it was found that under the restrictions of the building code as to load on foundations, it would be possible to put up a structure 2,000 feet in height on a lot 200 feet square. The building would weigh over 500,000 tons, and its weight would be so great that, in spite of the vast height, there would be a factor of safety of 8 against overturning by wind pressure, even in a stiff gale. If the tower were constructed and equipped similarly to the Singer Building, the cost would be $60,000,000. As a matter of fact, the limit upon the height of tall buildings is to be found neither in the inherent weakness of the structure, nor in the danger of upsetting in a gale of wind. The limit is determized by a clause in the Building Code of the city of New York, which says that the maximum pressure on the rock below the foundations, if caisson foundations are used, must not exceed 15 tons per square foot. As a matter of fact, the practical limitations upon height would come from the increasing thickness of the lower walls; for the Building Code states that the walls of the steel and masonry type of building must be 12 inches thick for the uppermost 75 feet of their height, and must be increased 4 inches in thickness for every 60 feet below that. Structurally considered, this provision of the Building Code is unnecessary, since the weight of the walls at each story is carried directly upon the steel framework at the base of that story; and there is, therefore, no structural necessity for making the walls at the base of a 20-story building more than 12 to 18 inches thick.

There is a movement among our architects to limit the height of buildings in such a way as to permit the erection of tall buildings only under restrictions which will insure that they do not unduly exclude the light from the streets or from one another. This desirable object is to be secured by a law making it necessary, after a building has been run up so many stories on the building line, to step back a specified distance before erecting the next series of stories, the offsetting being repeated as often as is necessary to admit the desired amount of light to the adjoining street. The center of the building plot is to be reserved for the main, tower-like, portion of the building, which may be carried up as high as the owner may wish. The question of the architectural treatment of tall buildings is one of the most difficult problems that has ever presented itself to the profession. In the earlier structures the architects made the mistake of trying to mitigate the appearance of height by introducing heavy horizontal elements in the way of cornices and offsets; but the results were not pleasing architecturally. The modern office building is first and last a tower, and as a tower it should be treated. Those architects who have recognized this fact, and have emphasized the vertical as against the horizontal lines, have produced the most successful buildings. Our illustrations include two buildings, the Singer and the Metropolitan Life, whose capacity has recently been enlarged by the erection of additions, in the form of towers of unprecedented proportions.

Although the Singer tower measures only 65 feet on each side, the top of the dome stands 612 feet above the sidewalk. It is erected upon thirty-four caissons sunk to bedrock, which, in some cases, lay 90 feet below the street level. From an engineering point of view, the most interesting feature is the method of framing the steel skeleton to enable it to resist the heavy wind pressure, when the thunder squalls of summer and the heavy gales of winter sweep over Manhattan. It was impossible to run continuous diagonal truss members across the building from wall to wall, because such an arrangement would have encroached upon the window space. Therefore it was decided to consider the structure as being built up of four square corner towers, and a central tower forming the elevator well, with wind bracing running continuously through each wall of each tower from top to bottom, the five towers being tied together in lateral planes at the various floors. The corner towers are 12 feet square from center to center of columns. This arrangement provides an open space 36 feet in width, free from diagonal bracing, extending down the center of each face of the building, and these faces are occupied by large bays filled in with glass, as shown in the accompanying illustration. This method of bracing involved high stresses in the chords of the trusses which, in this case, are the vertical columns of the tower, and the latter are of unusually heavy construction. The wind pressure at 30 pounds per square foot exercises a total overturning moment on the whole tower of 128,000 foot tons. Although the total weight of the tower is 23,000 tons, the wind pressure would have a tendency to lift the windward side of the building, the total uplift on a single column amounting, for maximum wind pressure, to 470 tons. To provide against this the columns are anchored to the caissons, and the margin of safety against lifting is in no case less than 50 tons to the column. The effect of the wind pressure on the leeward side of the building also affords some interesting figures. Thus, the total dead load at the foot of one of the leeward columns is 289.2 tons, which represents the weight of the steel work and masonry. The live load, which includes furniture, fittings, and the maximum crowd of occupants, totals, at the foot of this column, 131.6 tons. The downward pressure on the leeward side of the building due to wind pressure is 758.8 tons, and this, added to the dead and live loads, brings the total load on these columns up to 1,179.6 tons. The architectural treatment of the building is decidedly pleasing, and Mr. Ernest Flagg, the architect, is to be congratulated in having done so well in a field for which there was no precedent.



Showing the diagonal wind bracing at each corner. The tower is 612 feet high; its total weight is 23,000 tons.

CONSTRUCTION OF THE SINGER TOWER.

Rises 363 feet above a triangular base. There are 23 stories in the tower. Total floor space, 117,000 square feet.
Copyrighted 1905 by Irving Underhill.

THE TIMES BUILDING

Popularly known as the "Flatiron." This building, 310 feet high, stands on a triangular base measuring 215 feet on Broadway, 198 feet on Fifth Avenue, and 86 feet on 23d Street. The site cost $2,500,000.
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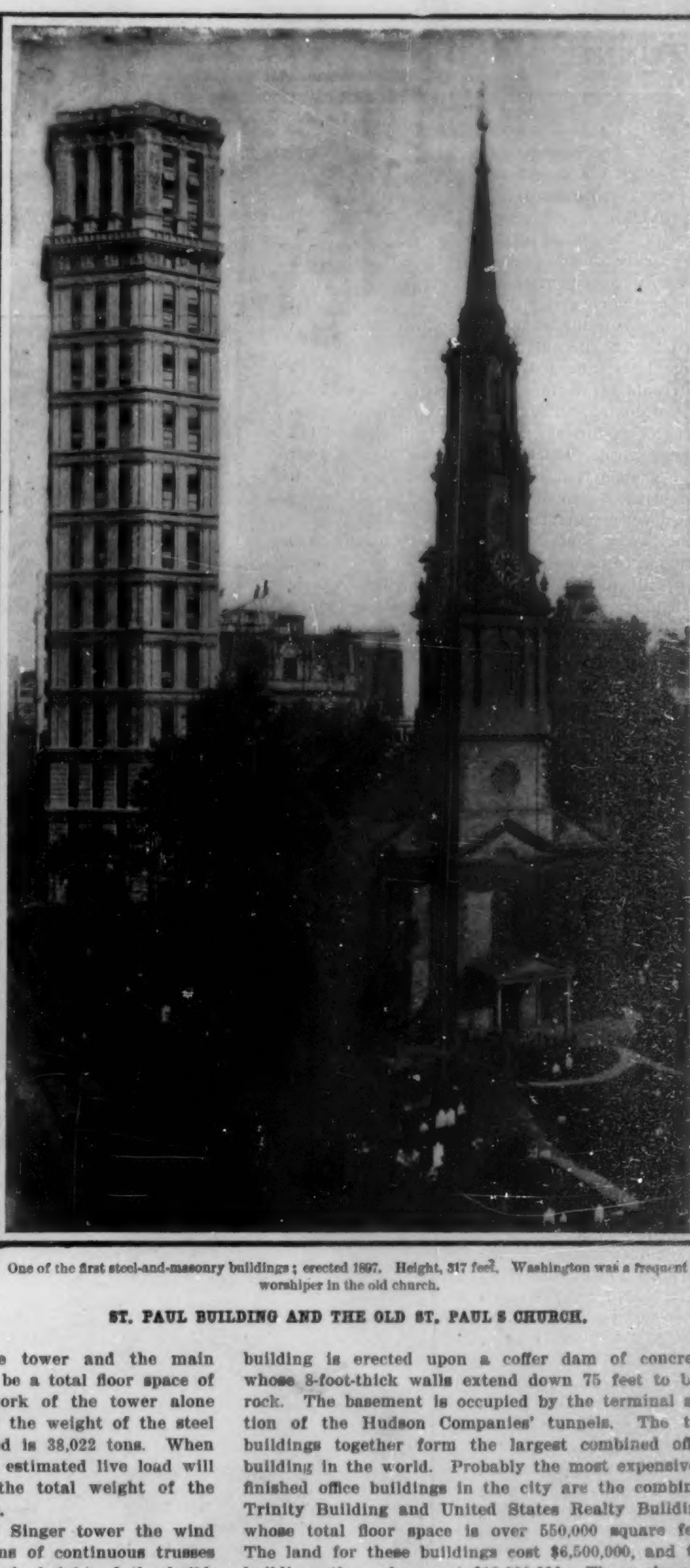
THE FULLER BUILDING.

Tower measures 75 feet by 85 feet, extends 700 feet above sidewalk, contains 50 stories, includes 8,100 tons of steel in its framework, and weighs 38,022 tons. In the building and tower combined there are over 25 acres of floor space.

THE METROPOLITAN LIFE TOWER, 700 FEET IN HEIGHT; THE LOFTIEST BUILDING IN THE WORLD.

The City Investing Building, 485 feet high, contains 31 rentable stories. It covers a lot 124 feet by 308 feet and its total floor area is 670,000 feet.

THE CITY INVESTING BUILDING AND THE SINGER TOWER.



One of the first steel-and-masonry buildings; erected 1897. Height, 317 feet. Washington was a frequent worshiper in the old church.

ST. PAUL BUILDING AND THE OLD ST. PAUL S CHURCH.

The combination of red brick and buff stone with the bronze and copper finish of the windows and dome is decidedly pleasing, and the disposition of the windows throughout the vast reach of forty-two stories proves that it is possible to get away from that pepper-box appearance which is one of the unsightly features of the façade of the average tall building.

Unquestionably the most striking of the lofty buildings of New York city is the stupendous steel-and-marble campanile which is being erected at the northwest corner of the Metropolitan Life Insurance Company Building, between Fourth and Madison Avenues and Twenty-third and Twenty-fourth Streets. The present building, which is ten stories in height, has a frontage of 200 feet by 425 feet. The tower has a base measurement of 75 feet by 85 feet, and extends a clear 700 feet above the sidewalk. The whole building is treated in the pure early Italian Renaissance style, which has been used also in the tower; and both tower and building are finished in Tuckahoe marble.

It takes but a glance at our illustration of this stupendous marble shaft to feel assured that when it is completed, it will be an object of decided architectural grandeur and beauty. Its height is so great that fully one-half of its bulk will rise absolutely clear of the cornice lines of New York city's 20-story buildings. The highest point of the tower will overtop the highest point of the Montclair Hills in New Jersey by about 30 feet; and when the shadows of evening are falling upon the street below, the summit of the tower will be crimsoned with the rays of the sun that has already set behind the Orange Mountains. The most lofty rentable offices will be those of the forty-first story, whose floor will be 526 feet above the sidewalk. The windows of these offices will be at the same elevation as the lookout windows at the top of the Washington Monument. The table of dimensions and weights as obtained from the architects, Messrs. M. Lebrun & Sons, runs into large figures. In the tower there will be fifty stories, and in the tower and the main building combined there will be a total floor space of 25 acres. The steel framework of the tower alone weighs about 8,100 tons, and the weight of the steel work, masonry, etc., combined is 38,022 tons. When the building is occupied, the estimated live load will be 5,591 tons, bringing up the total weight of the whole building to 43,613 tons.

We have seen that in the Singer tower the wind stresses are resisted by means of continuous trusses extending throughout the whole height of the building. In the Metropolitan tower the frame is stiffened against distortion by means of heavy knee braces at the intersection of the vertical columns and the horizontal floor beams. The stresses due to wind pressure reach a very high figure, and call for a large increase in the sections of the columns, etc., to provide for them. In the principal columns on the leeward side of the tower, the load due to dead and live loads combined is 7,500,000 pounds; and the load due to wind pressure is 2,900,000 pounds, which brings the total load up to 10,400,000 pounds. Similarly, the corresponding columns on the windward side are relieved of pressure, the maximum load being reduced from 7,500,000 pounds to 4,600,000. This shows that even under the heaviest storms that may blow against it, there will at no time be any tendency on the part of the building to turn over on its foundations.

Limitations of space prevent our pursuing this subject any further than to give some particulars of a few of the most recent and notable buildings. The Metropolitan Building just described is the largest single office building in the world, containing, as we have seen, over 25 acres of floor space. The next to that is the City Investing Building, with thirty-three stories and a total height of 485 feet. The total floor space is 670,000 square feet, and it can accommodate 6,000 people. The Terminal Building is in two sections, on of which has 26,000 square feet of available area on each floor, and the other 18,000 square feet. This huge building is erected upon a coffer dam of concrete, whose 8-foot-thick walls extend down 75 feet to bedrock. The basement is occupied by the terminal station of the Hudson Companies' tunnels. The two buildings together form the largest combined office building in the world. Probably the most expensively finished office buildings in the city are the combined Trinity Building and United States Realty Building, whose total floor space is over 550,000 square feet. The land for these buildings cost $6,500,000, and the buildings themselves cost $10,000,000. The main roof is 300 feet above the street, and the tower 360 feet. There are twenty-two floors, with five in the tower, and 5,000 people can be accommodated in the two buildings. For the particulars of other notable buildings, reference may be made to the descriptive matter given beneath the cuts on pages 401-3.

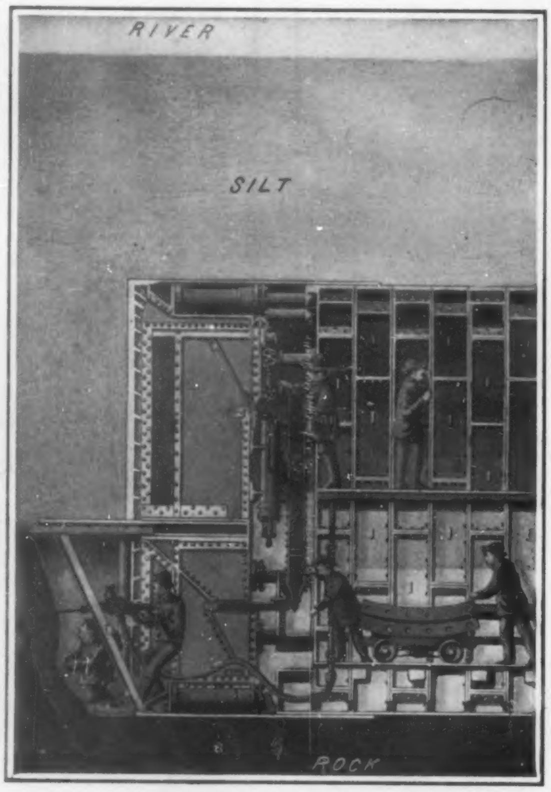
In closing this chapter, emphasis must be laid upon the fact that, had it not been for the development of that distinctively American device, the high-speed elevator, the present skyward growth of our modern cities could never have taken place. In one single building, the City Investing Building, there is a row of no less than twenty-one elevators for passenger service alone. The speed of travel has risen to 400 feet a minute for the local and 700 feet a minute for the express elevators.

The necessity of increasing the number of docks continues to be felt at Hamburg no less than at other ports abroad, in spite of the already extensive accommodation for shipping existing there. Since the last considerable extension took place, viz., in 1897-8—though two new docks have been opened since then—the aggregate tonnage of sea-going vessels visiting this port has increased from about 7,500,000 to 12,040,000 register tons in 1907. In consequence of this remarkable development, and although two new docks were opened in 1903, the want of sufficient room for quay berths has been acutely felt.

TUNNELS AND SUBWAYS

The fact that the most important section of New York city is located on a long and narrow island, flanked by broad and deep rivers and waterways, is largely responsible for the present activity in the construction of subways and tunnels. In the earlier days of the history of the city, passenger traffic was taken care of by lines of surface cars and ferries. These were supplemented, about thirty years ago, by the construction of four lines of elevated railways running the entire length of Manhattan Island. The Brooklyn Bridge, opened some five years later, afforded a greatly needed relief to the rapidly growing travel between New York and Brooklyn. The next step in the development of facilities was the electrification of the surface roads, which was followed in its turn by a change from steam to electric traction on the elevated system. Concurrently with these last developments, the construction of three additional bridges of unusually large capacity was commenced across the East River. One of these, the Williamsburg Bridge, was opened some four or five years ago; the Blackwell's Island Bridge will be opened as soon as the necessary changes to render it usable have been made; and the Manhattan Bridge should be thrown open to the public within the next two years.

In spite of the greatly increased accommodations provided by these enterprises, it became evident, even before they were completed, that the rapid growth of the city, and the even more rapid growth of travel, would necessitate the provision of additional means of transportation; and that any future roads which might be built must be placed below street level. It was realized, moreover, that the construction of bridges across the Hudson River was too difficult and costly for the city to depend upon any relief in this direction. After a protracted discussion of its feasibility, the question of constructing a subway system was submitted to the public vote, and a decision was given in its favor. A Rapid Transit Commission, consisting of leading men of affairs in the city, was formed and under their very able direction a comprehensive scheme of subways was laid out, and the portion of it which is now in operation constructed. The first section to be completed extends from the City Hall, New York, to Kingsbridge beyond the Harlem River, with a branch running from Ninety-sixth Street northeasterly to the Bronx. From City Hall Park to Ninety-sixth Street there are four tracks, the two outer tracks for local service, and the two inner tracks for express trains. North of Ninety-sixth Street, on the westerly branch of the road, the Subway contains, first three tracks and then two; the easterly branch from Ninety-sixth Street contains two tracks. Subsequently, a two-track Subway was constructed from City Hall Park to Flatbush Avenue, Brooklyn, the route lying below Broadway to the Battery and then under the East River in two tube tunnels. The section of the road from City Hall northward was opened in 1904, and the section from City Hall to Flatbush Avenue in Brooklyn, in 1907. The contract for the first section was let for \$35,000,000; the equipment, power station, purchase of the real estate, etc., cost an additional \$12,000,000, bringing the total cost up to \$47,000,000. From the very first the Subway has proved an unqualified success. The express trains on certain sections of the line reach a speed of 45 miles an hour between stations, and run at an average speed, including stops, of between 25 and 30 miles an hour, the average depending upon the delay at stations. Express trains are made up of eight cars, of which five are motor cars. Local trains, which have a speed of about 16 miles an hour, including stops, are made up of six cars, four of which are motors. Before the opening of the line, it was hoped by the most optimistic that the system would develop a maximum capacity of from 375,000 to 400,000 passengers a day. As a matter of fact, on holidays and other special occasions, over 600,000 have been carried. The opening of the Brooklyn tunnel afforded greatly needed relief to the Brooklyn Bridge. It became immediately popular, and the city, as soon as funds are available, will build a branch line through southern Brooklyn to Coney Island. At present, there is under construction a loop-line which will connect the Manhattan terminals of the Williamsburg and Brooklyn bridges. In the first section to be completed the tunnels were built chiefly by the cut-and-cover method, and, except where they pass through rock, they are built of steel I-beams and structural shapes imbedded in concrete. For the later construction reinforced concrete was used. In view of the speed and rapidity of the service and the enormous volume of traffic handled, the New York Subway must be regarded as the most successful, as it is the largest and most important underground railway in the world. It is operated on the third-rail system.

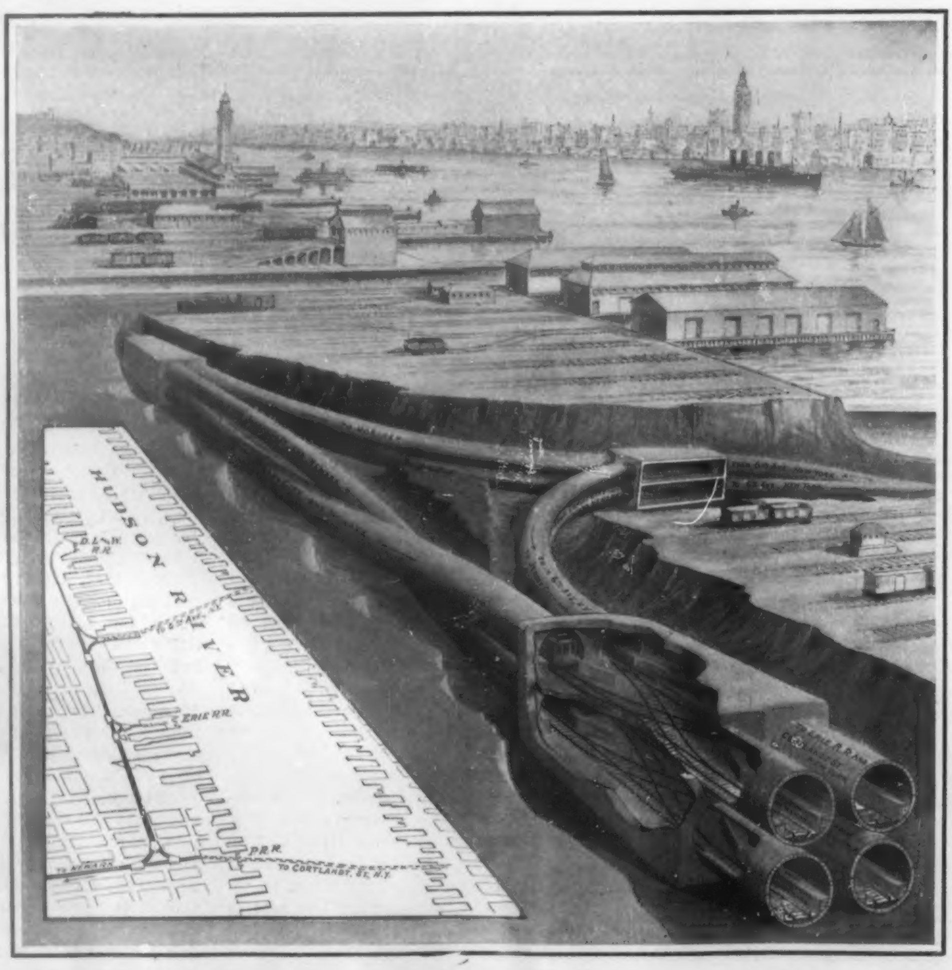


Showing projecting roof for protecting workmen while blasting out a projecting reef of rocks.

SECTIONAL VIEW OF HUDSON RIVER SHIELD.

To provide the necessary power for operating the Subway, which, as we have noted, has carried over 600,000 passengers in a single day, has called for the construction of what is to-day the largest power station of its kind in the world. The plant, which is located at Fifty-ninth Street, is housed in a building 200 feet in width by 690 feet in length, which is divided centrally by a wall separating the engine room from the boiler room and coal bins. These coal bins, which are located immediately below the roof and above the boiler room, have the enormous capacity of 25,000 tons of coal. The coal is fed by gravity to the hoppers of the mechanical stokers, from which it is automatically fed to the furnaces.

One who has never visited a plant of this character can have no idea of the imposing appearance presented by the long line of engines and generators in the engine room. In the present case the equipment consists of nine reciprocating engines, the largest of their type ever built, and three steam turbines. The reciprocating engines are of the well-known type developed by the Allis-Chalmers Company of Milwaukee, Wis., and they are superb specimens of the engine builder's art. Because of the advent of the steam turbine with its peculiar fitness as a drive for large generator units, it is probable that these engines will stand as the "last word" in the history of the development of the reciprocating engine. When standing in the gallery at the power station and looking down the long perspective of the engine room, one cannot but feel that, whatever advantages of an economical kind the steam turbine has introduced, it has robbed the engine room of much of its spectacular features. New York city was already familiar with the Allis-Chalmers engines of this type because of their installation in that other great power plant, at Seventy-fourth Street and the East River, which provides power for the operation of the elevated roads. The Fifty-ninth Street engines are generally similar to these; but they include certain improvements in valve gear and in some minor details. The engines are rated at 8,000 horse-power, with a maximum overload of 12,000. Each consists of two compound condensing engines, one at each end of the crankshaft, with the alternator carried at the center of the shaft between the engines. The 44-inch high-pressure cylinder is placed horizontally, and the 88-inch low-pressure cylinder vertically, with the two connecting rods of each engine taking hold of a common crankpin. The stroke is 60 inches. The two cranks are set at an angle of 135 degrees to each other, an arrangement which gives eight impulses to the shaft at equal intervals in each revolution. The crankshaft has a diameter of 37 inches at the center and 34 inches at the bearings. The crankpins measure 18 inches by 18 inches, and the crosshead pins are 12 x 12 inches. The weight of



These caissons, 45 feet wide, 45 feet deep, and 106¼ feet long, the largest ever constructed, are built of reinforced concrete. They provide a double-deck system which eliminates dangerous crossovers between trains running in opposite directions.

HUGE DOUBLE-DECK CAISSONS AT JUNCTIONS OF HUDSON RIVER TUBES WITH THOSE ALONG THE JERSEY SHORE.

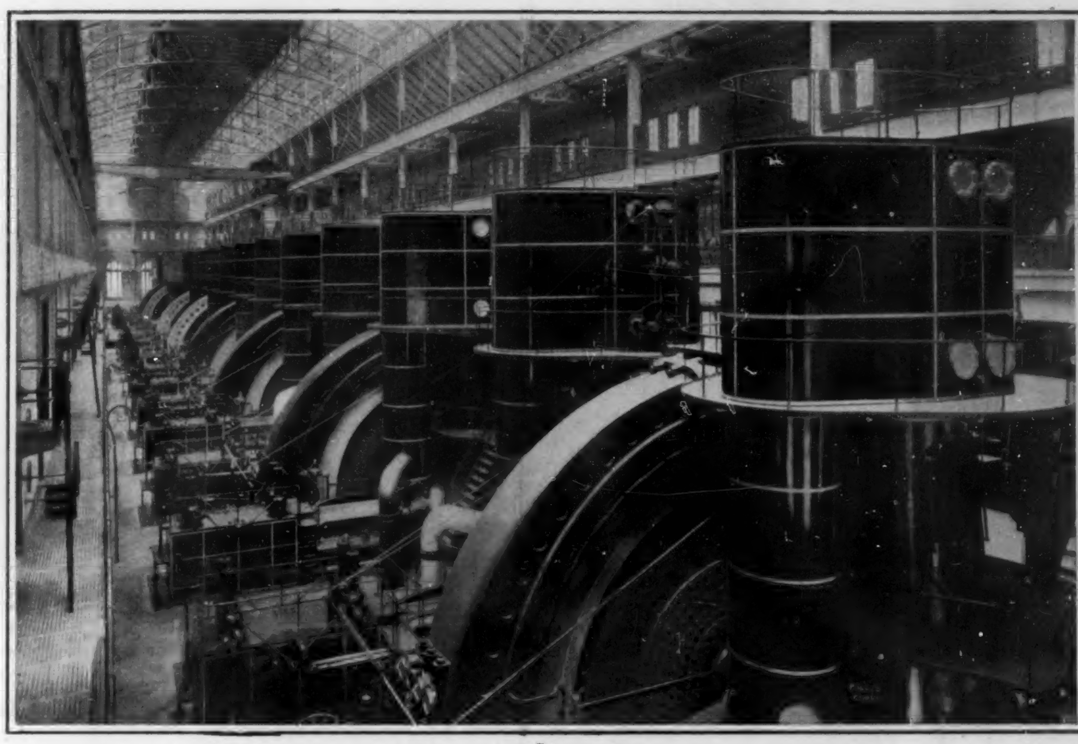
each pair of engines is 720 tons. The steam pressure is 175 pounds, and the steam consumption at the rating of 8,000 horse-power is about 13 pounds per horse-power per hour. At the far end of the station are three Westinghouse turbines of 1,250 kilowatts rating. The maximum horse-power of this station, under overload, is about 130,000 horse-power.

Next in importance to the Rapid Transit Subway, which, it should be mentioned, is owned by the city, is an elaborate system of subways and tunnels, constructed by an independent concern known as the Hudson Companies, to afford direct rail communication between Jersey City and New York. For the beginnings of this enterprise we have to go back twenty-five years, to the time when Mr. De Witt Clinton Haskin, one of the active spirits in the building of the Union Pacific Railway, commenced the construction of a tunnel for the use of steam trains. The scheme met with many difficulties and disasters. It was abandoned in 1882; started again in 1890 by an English company; and ultimately was taken in hand by a corporation known as the New York and New Jersey Railroad Company; which, ultimately, under the successive names of the Hudson Companies and the Hudson and Manhattan Railway Company, succeeded in pushing the great scheme through to completion. The credit for this enterprise is chiefly due to President McAdoo. The great value of the road lies in the fact that it intersects the trunk roads which have their termini in New Jersey, and enables passengers to transfer, under cover, to trains which carry them direct to the shopping, hotel, and financial districts on Manhattan Island.

The system consists in Jersey City of a two-track road, placed in two separate 15-foot tubes, which extends from the Delaware, Lackawanna & Western Railroad terminal south to the terminal station of the Pennsylvania Railroad. Ultimately, it will be carried down to connect with the terminal of the Central Railroad of New Jersey. At Fifteenth Street it is intersected by twin tunnels which pass beneath the Hudson, and are carried up Sixth Avenue to Twenty-third Street, and ultimately will be extended to Thirty-third, where they will be in touch with the Pennsylvania Railroad terminal. A branch line will be constructed at Ninth Street to connect with the Rapid Transit Subway. Below the Pennsylvania station, at a depth of 80 feet, there has been constructed a large station, access to which will be had by elevators from the Pennsylvania terminal. From this station twin tubes extend below the Hudson River and Manhattan Island to a large terminal station between Cortlandt and Fulton streets, above which has been constructed the large terminal office building to which reference is made elsewhere in this issue.

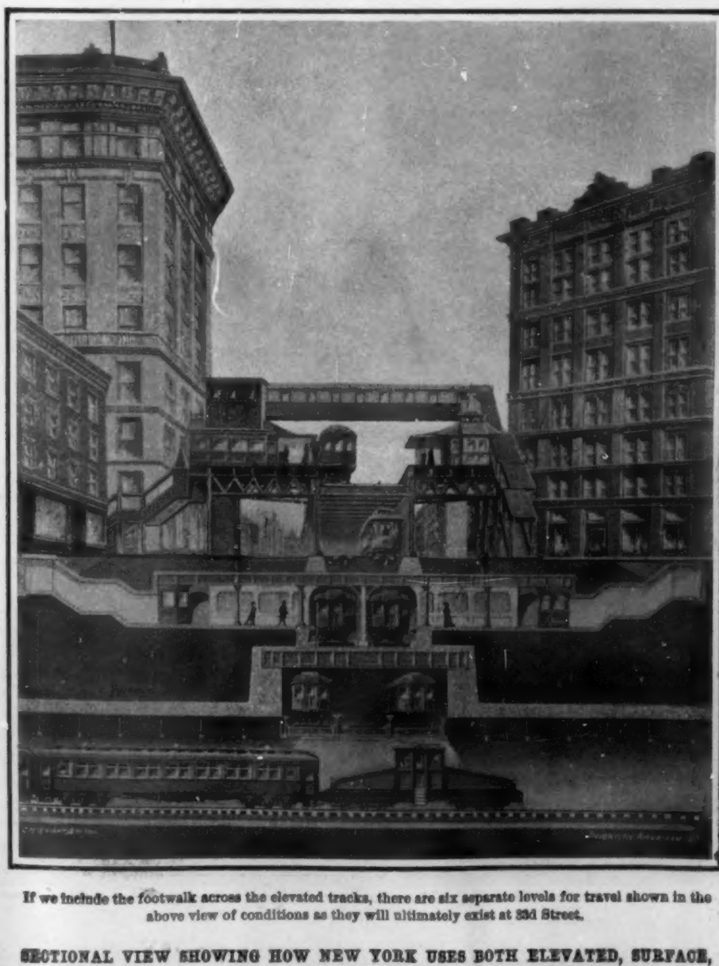
Because of the difficulties encountered in passing beneath the Hudson River, and the novel methods which were adopted to meet them, the engineering features of this system are particularly interesting. All four tunnels were driven by the shield method, which is too well known to call for any description at the present time. The tunnels are 15 feet in diameter internally, and it was originally intended to line them entirely with concrete. After they had been driven, however, it was found that they presented such absolute stability as to render the use of concrete unnecessary. Instrumental observations have failed to show any signs of settlement; and, as far as their stability is concerned, the tubes may be pronounced a decided success. Records for rapidity in driving were broken during the prosecution of the work, the rapid advance being due to the adoption of a method altogether novel and bold. In previous work with

(Continued on page 414.)



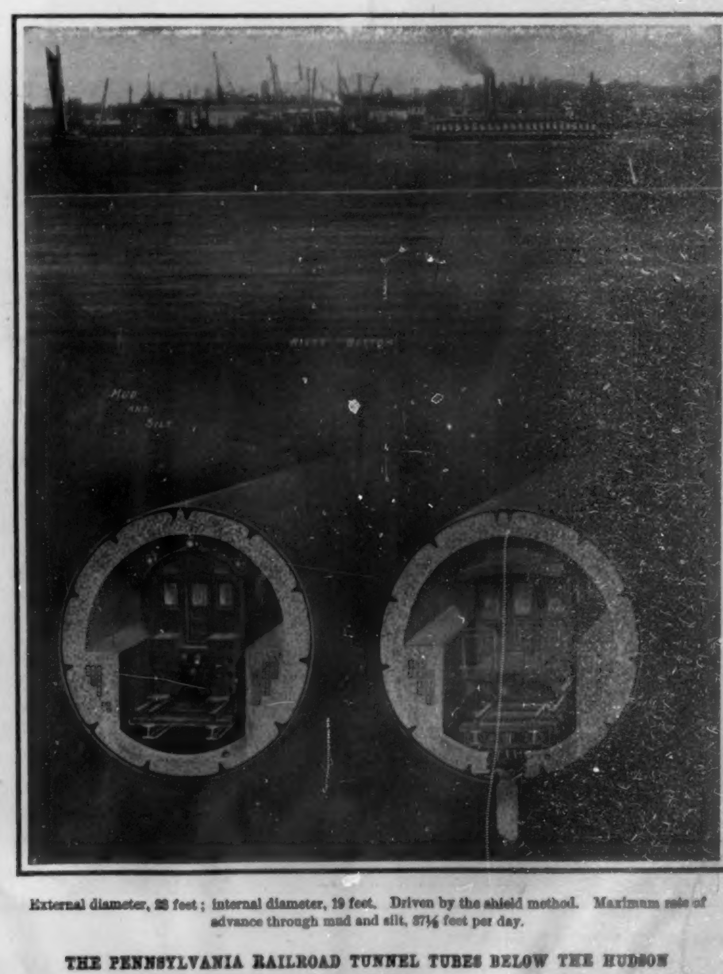
This power station, the largest for traction purposes in the world, is 200 feet wide by 790 feet long. It contains nine reciprocating Allis-Chalmers engines of 12,000 overload horse-power and three steam turbines of 1,800 horse-power.

THE NEW YORK RAPID TRANSIT SUBWAY POWER STATION AT FIFTY-NINTH STREET.



If we include the footwalk across the elevated tracks, there are six separate levels for travel shown in the above view of conditions as they will ultimately exist at 33d Street.

SECTIONAL VIEW SHOWING HOW NEW YORK USES BOTH ELEVATED, SURFACE, AND TUNNEL ROADS IN PROVIDING FOR ITS EVER-GROWING TRAFFIC.

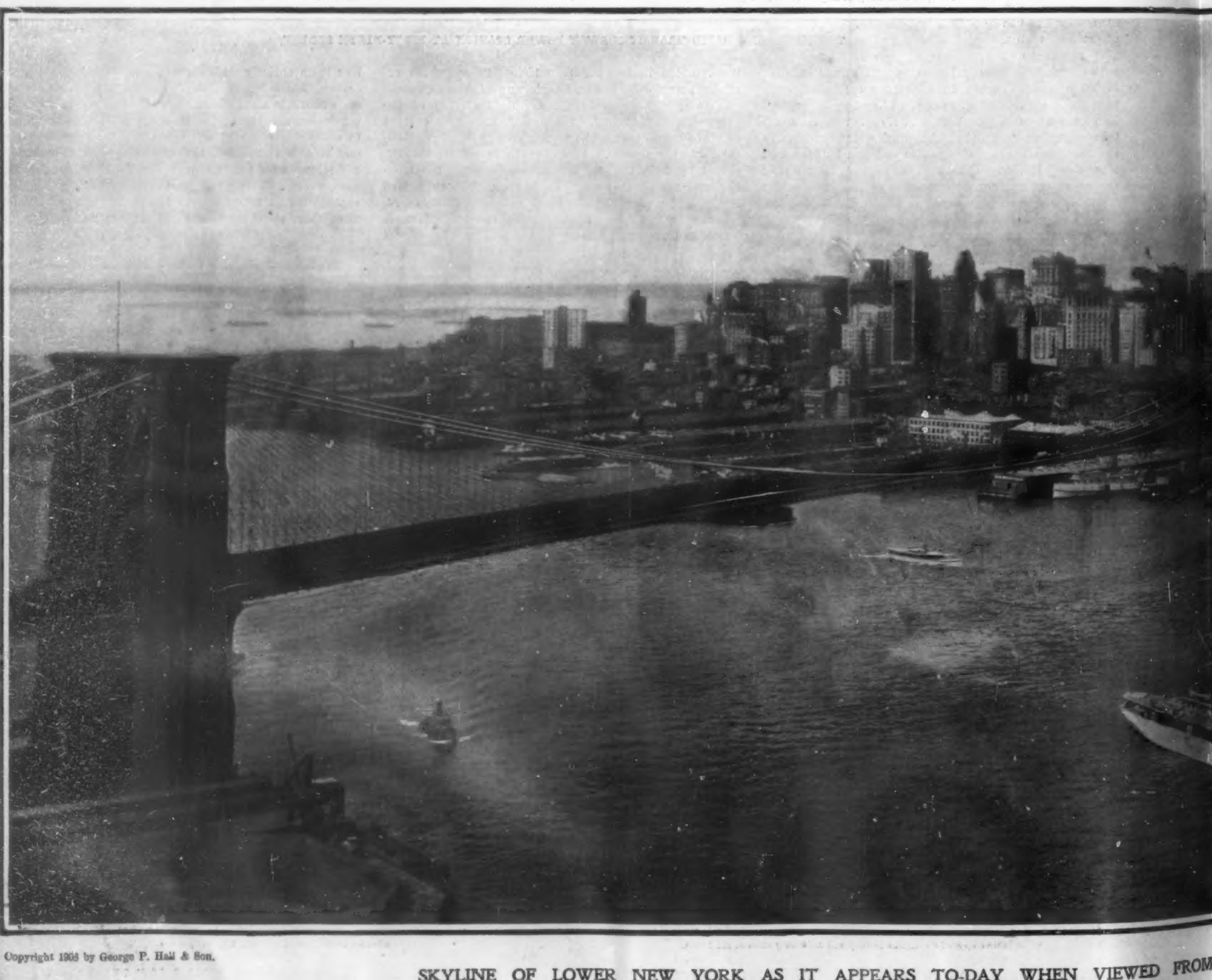


External diameter, 23 feet; internal diameter, 19 feet. Driven by the shield method. Maximum rate of advance through mud and silt, 37½ feet per day.

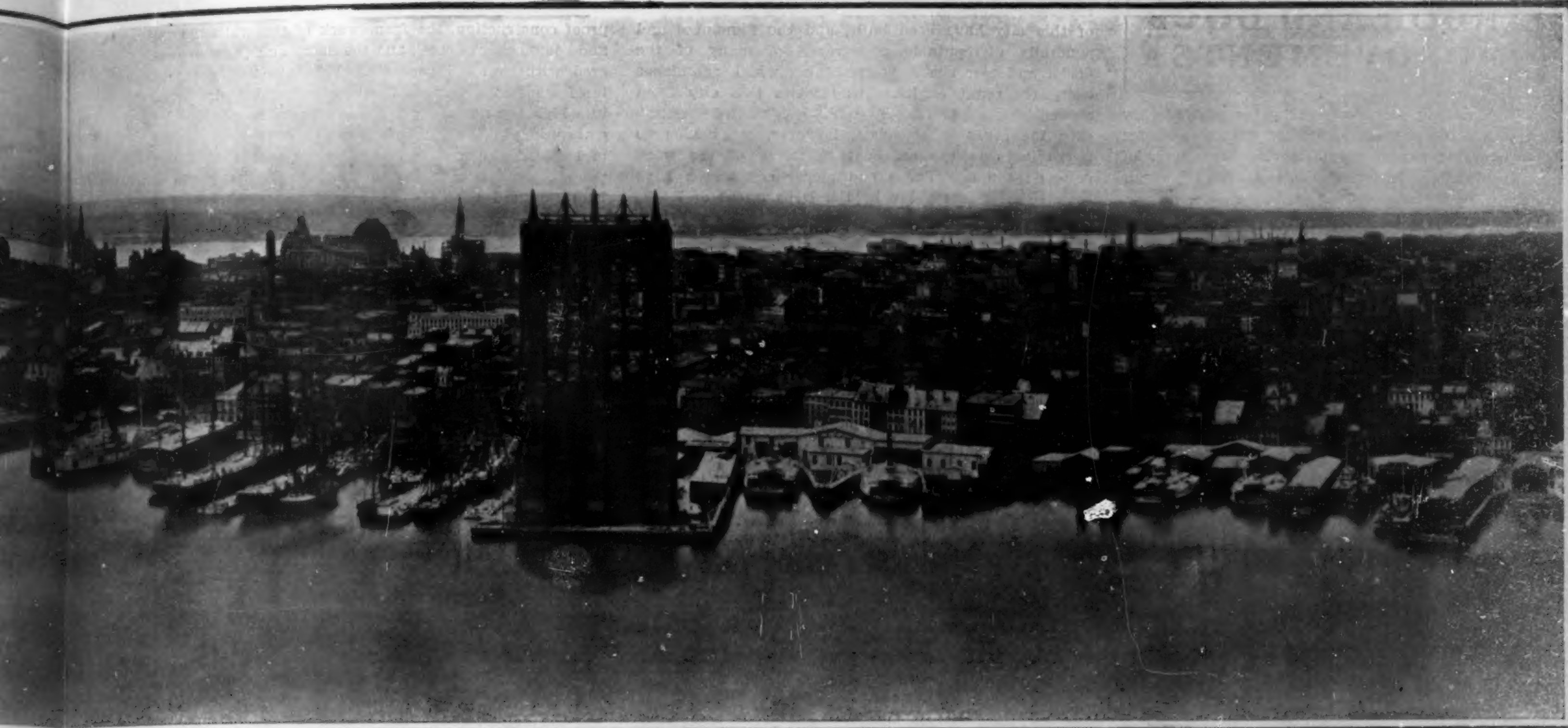
THE PENNSYLVANIA RAILROAD TUNNEL TUBES BELOW THE HUDSON RIVER.

From a photograph owned by the Otis Elevator Co.

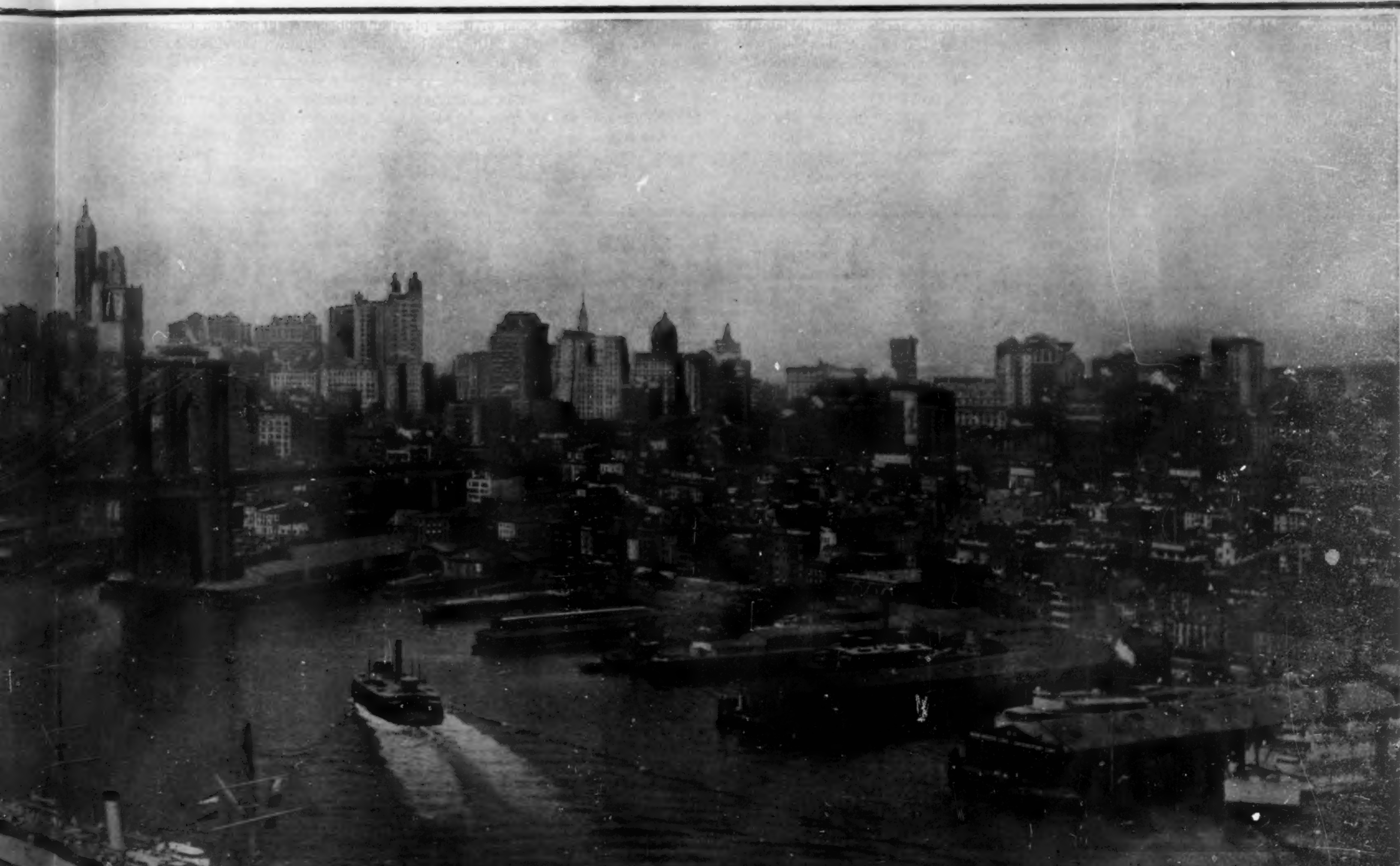
LOWER NEW YORK AS IT APPEARED IN 1875. REPRODUCED FROM A PHOTOGRAPH TAKEN FROM TH



SKYLINE OF LOWER NEW YORK AS IT APPEARS TO-DAY WHEN VIEWED FROM



FROM THE TOP OF THE BROOKLYN TOWER DURING THE CONSTRUCTION OF THE BROOKLYN BRIDGE



FROM THE TOP OF THE BROOKLYN TOWER OF THE NEW MANHATTAN BRIDGE

HARBOR AND DOCK IMPROVEMENTS

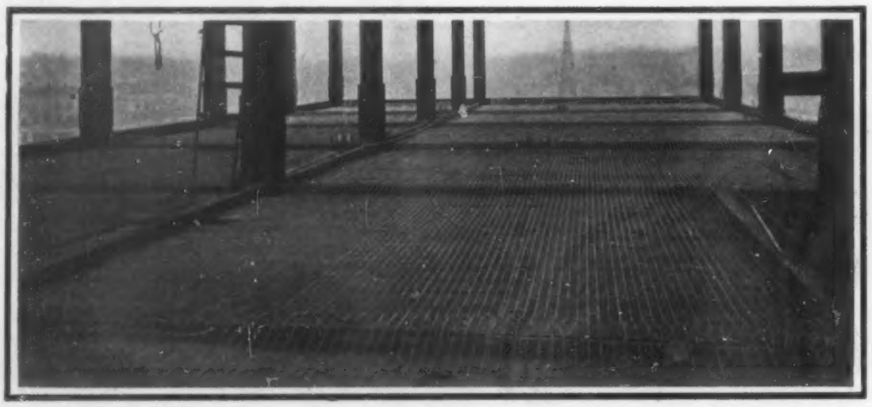
The commanding position held by the port of New York on the seaboard of the United States is shown by the fact that out of a total foreign commerce of the United States of $3,581,000,000, $1,613,000,000 represents the foreign trade of the port of New York alone. These are the figures for the year 1907; and the money value of New York's foreign commerce translated into tonnage means that no less than 12,000,000 tons of freight passed in or out of the harbor entrance at Sandy Hook, and was handled at the multitudinous docks which line the far-reaching shore line of the city.

The proud commercial position held by New York, as shown by the fact that the city handles nearly one-half of the nation's foreign commerce, is due to its commanding geographical position and to the unusual extent and excellent character of its harbor facilities. The total frontage of the city on the water is 444.80 miles, and of this 125.10 miles is available for shipping. The available frontage is divided as follows: 5.33 miles is used by the various steam railroads; 3.61 miles is devoted to foreign steamship service; 3.11 miles to domestic steam service; 23 miles of frontage is owned by the United States government; the various parks of the city have a frontage of 23 miles; and 47.28 miles of frontage may be described as miscellaneous.

In an analysis of the accommodations of the port of New York for water carriers in relation to railroads, warehouses, and the active business of the city, dealing with the North River south of Seventy-second Street, and the East River south of Forty-fourth Street, it was recently shown by Mr. W. G. Wilgus that fourteen of the piers are devoted to railroads, exclusive of ferries; thirteen piers to the accommodation of foreign steamships; twenty-three piers are used for coastwise, river, and Sound lines; twenty-two for ferry purposes; and fifteen for municipal purposes.

It must be confessed that much of the pier and dock construction of the city falls lamentably below the standard for a port of the vast importance of New York. This is particularly true of the older docks, ferry houses, pier sheds, etc., built at a time when capital was not so plentiful, and engineering construction was hampered by considerations of economy. The disparity between the magnificent scale upon which the office buildings, bridges, tunnels, and waterworks of this city have been built, and the flimsiness and generally disreputable appearance of many of the docks and pier sheds, is something which astonishes every observant engineer who visits this city from abroad.

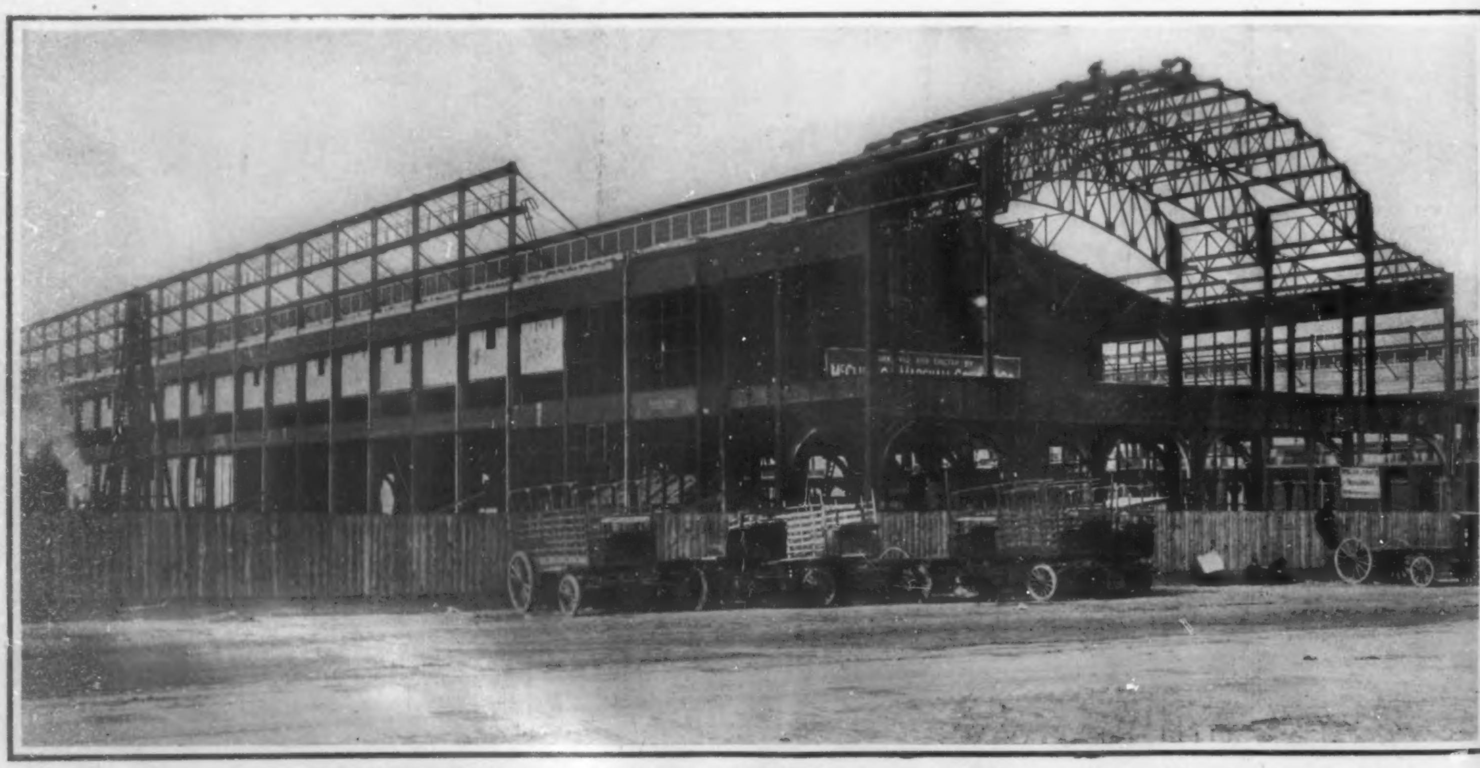
In making this criticism, however, we hasten to pay tribute to the excellent character of the work done on the new docks and pier sheds, which have been built of late years by the Department of Docks and by some of the leading steamship companies. Particular credit is due to the German and other foreign steamship companies for the handsome docks which they have built during the last decade along the Jersey shore of the Hudson River at Hoboken. The Department of Docks also has reason to be proud of the long stretch of new docks and pier houses extending north from Christopher Street. The size of these last-named piers, and the excellent character of the double-deck sheds erected upon them, are fully commensurate with the dignity of the great port of New York.



WELDED WIRE CLOTH AND CONCRETE SYSTEM OF FLOORING USED IN THE FLOORS OF THE NEW CITY DOCKS.

We present illustrations of Pier 56, one of several now being built by the Department. It is 100 feet wide, 825 feet long, and is covered for its whole width by a two-deck steel-frame pier shed of absolutely first-class construction. The substructure of the pier is of the prevailing type in New York harbor, being carried upon piling driven into the silt of the river bottom to a firm foundation, the piling being heavily cross-braced in both directions. The lines of piles down the sides of the dock are cut sufficiently lower than the piles under the body of the dock to allow of the placing of a side cap. Above the piles are placed the cross caps, and above these again are the rangers, or stringers. On the stringers are laid two thicknesses of creosoted planking. This is followed by a layer of armored concrete, and above this a finishing layer of asphalt. The pier-shed building is of thoroughly fireproof construction, the framework of the walls, floors, and roofs being of steel, and the floors and the roof covered with armored concrete. This armored concrete is of what is known as the Clinton welded-wire type, in which the necessary tensile strength is afforded by embedding in the concrete a heavy wire mesh, made of steel wire drawn under a tensile strain of 60,000 pounds per square inch. Of late years it has come to be recognized that the value of steel wire reinforcement in concrete depends upon the quality of the bond between the wires at their intersections, and between the surface of the steel and concrete. Where the bond is imperfect, there would be a tendency to movement between the adjacent materials and, of course, such movement means an enormous loss of strength. In the ideal armored concrete, there should be no movement of the steel in the concrete, nor of the separate members of the steel reinforcement in regard to one another, and this is particularly true of wire-mesh reinforcement as used in slab flooring. To guard against such movement, the Clinton wire cloth is welded at every intersection. This has the double advantage of preventing movement of the wires upon one another, or movement of the whole mesh within the mass of inclosing concrete. The combination of concrete deck, floor, and roof with walls of structural steel covered with corrugated iron, provides an absolutely fireproof construction, and this fact, taken with the broad dimensions and lofty headroom of these piers and sheds, renders them comparable with the best construction at the first foreign seaports.

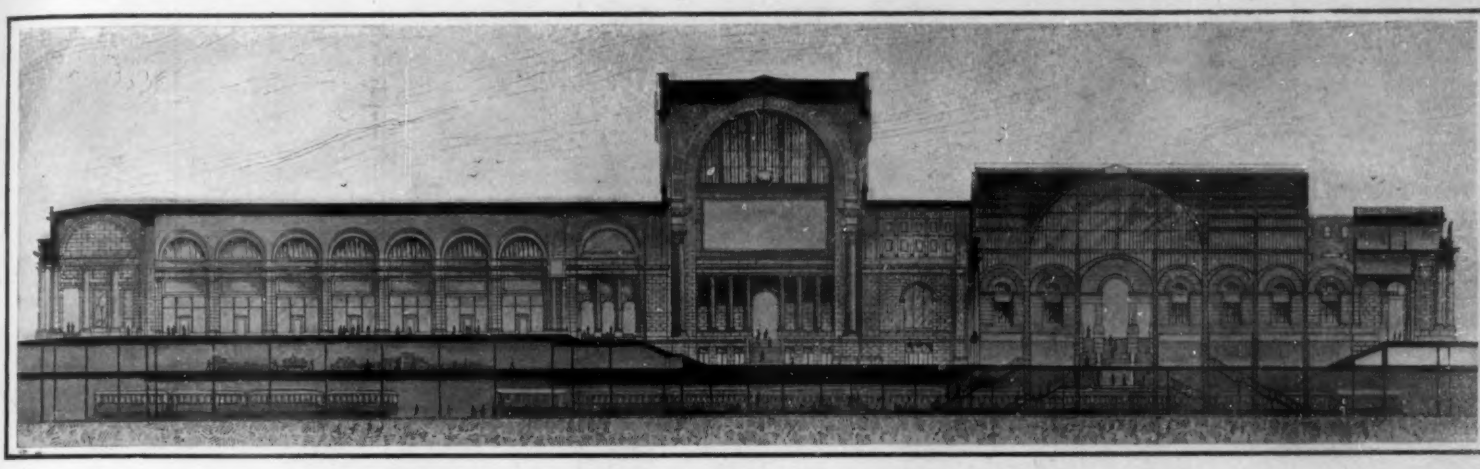
The last report of the Bureau of Construction and Repair, dated September 10, 1908, shows the vessels building for the United States navy to be in the following state of completion: Of the new battleships, the "South Carolina," building by William Cramp & Sons, was 58.1 per cent completed, and the sister ship "Michigan," building by the New York Shipbuilding Company, was 65.1 per cent completed. Of the two 20,000-ton "Dreadnoughts," the "North Dakota," building by the Fore River Ship and Engine Building Company, maintains its long lead over the "Delaware," building by the Newport News Company, the "North Dakota" being 50.1 per cent, and the "Delaware" 40.5 per cent completed. The five new destroyers are from 20 to 49 per cent completed, and the seven new submarines from 46.8 to 55.7 per cent completed.



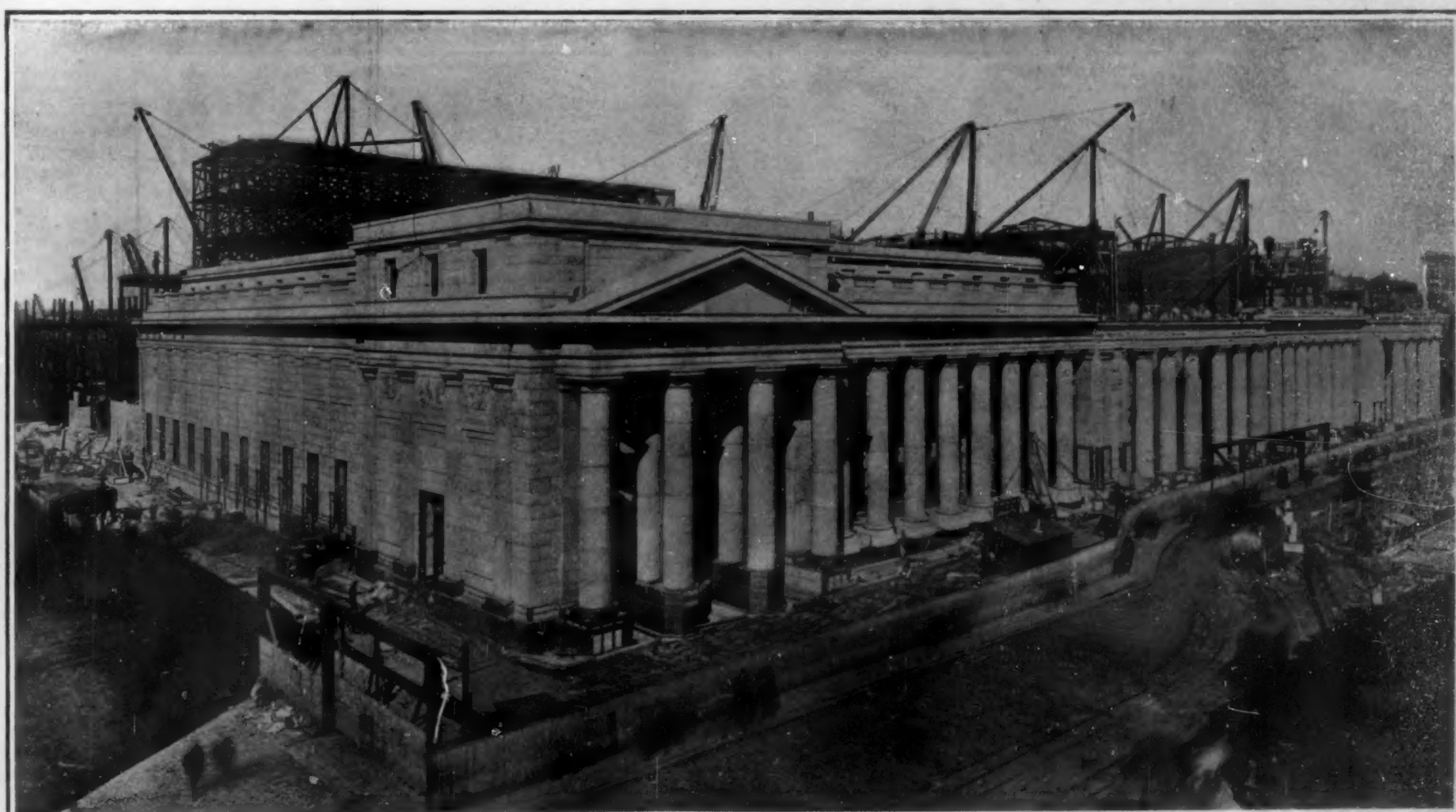
This view represents one of several new piers built by the Dock Department. They are 100 feet wide by 800 feet long. The pier sheds, constructed of steel and armored concrete, are thoroughly fireproof.

NEW PIER SHED OF PIER 57, BUILT AND OWNED BY THE CITY.

RAILWAY TERMINALS



SECTIONAL VIEW OF THE STATION ON A LINE RUNNING EAST AND WEST.



Length of station building, 774 feet; width, 433 feet; 69 feet in height. The handsome façade is faced with granite.

VIEW OF THE NEW PENNSYLVANIA TERMINAL STATION FROM SEVENTH AVENUE.

It is a curious anomaly that the leading city in the United States should, at the present time, have but a single trunk line terminal station within its borders; yet it is a fact that of all the great systems, the New York Central & Hudson River Railroad Company, alone, is in a position to run its trains directly into the city itself, the trains of the New York, New Haven & Hartford Railroad entering the same terminal under a rental agreement over the New York Central's tracks. The insular position of the major portion of New York city is responsible for this condition of affairs, the broad waters of the Hudson River having served, up to the present time, as an effectual barrier to prevent the other trunk roads from building their terminal stations on Manhattan Island. The most important of these, the Pennsylvania Railroad Company, after seriously considering the construction of a large railroad bridge across the Hudson with such assistance as it might be able to get from its smaller rivals, finally decided to carry its lines into Manhattan Island by tunnel instead of by bridge, and to build a large terminal station of sufficient capacity to handle the present traffic of the road and allow a considerable margin for future development.

PENNSYLVANIA RAILROAD TERMINAL STATION.

The work of building a Manhattan terminal station and the necessary connections was planned on the invariably generous scale with which this railroad undertakes work of the kind, the total estimated cost of the approaches, tunnels, and station, etc., being between ninety and one hundred millions of dollars. The tunnel section of the scheme has been handled in a previous chapter on Tunnels and Subways, and the present article will be given up mainly to a description of the great terminal yard and station.

The excavation for the new Pennsylvania terminal station as originally planned had a total width of about 500 feet and an extreme length of slightly over 2,000 feet. Roughly, it included four large city blocks. Much additional space was subsequently included for the accommodation of a power plant and the tunnel approaches to the station. The present site, which has reached the total area of 28 acres, is bounded by Seventh Avenue on the east, Tenth Avenue on the west, and on the north and south respectively by Thirty-third and Thirty-first Streets. The whole of this area will be covered at the lower level by the station tracks. At the easterly end, the tracks converge from twenty-one to four, and they extend beneath New York city, two of the tracks below Thirty-second and two below Thirty-first Street, ultimately passing in four separate tubes under the East River to Long Island City. At the westerly end, the tracks converge to two tracks, which pass beneath the North River in two separate steel-and-concrete tubes.

From what has been said above, it will be seen that the site of the station and yard is intersected by two important thoroughfares, namely, Eighth Avenue and Ninth Avenue. Eighth Avenue divides the site into two equal portions, the westerly half constituting the station yard, while the easterly half constitutes the station proper; and here it is that the imposing structure which forms the subject of our engravings is being erected. It has a frontage on the avenues of 433 feet, and on the streets of 774 feet, the sides of the building forming a perfect parallelogram. Below the surface of the street, and within the area covered by the building, the station will be divided into three levels, on the lowest of which will be the tracks at a depth of 40 feet below street grade.

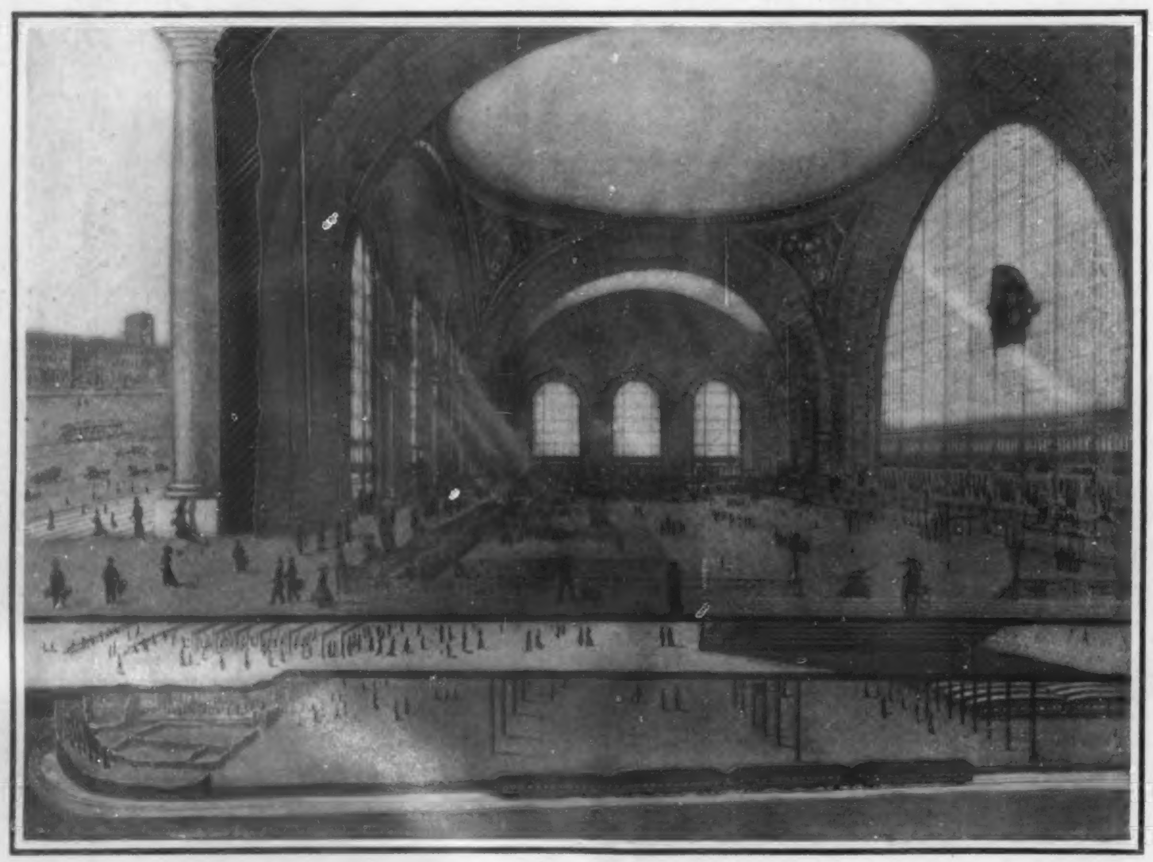
The question of the architectural treatment of a building of this magnitude, and to be used for this special purpose, was one that called for the most careful consideration, and New York city is to be congratulated on the fact that the Pennsylvania Railroad Company were willing to forego the opportunity to erect a huge office building above the station site, and preferred to memorialize its entrance into New York city by the erection of a magnificent and purely classic structure, commensurate with the importance of the company and the dignity of the great city in which it has at length found a fitting terminal.

The architectural design of the entire exterior is a Doric colonnade 35 feet in height, surmounted by a low attic, the average height of the elevation being 69 feet. In the center of the building, however, in order to accommodate the great waiting room, the roof of the structure reaches a height of 153 feet. The unusual extent of the building in area and its general type are suggestive of the great baths of ancient Rome; in fact, the architects of the building, McKim, Meade & White, took the baths of Caracalla, which are still magnificent in their ruins, as the inspiration of this architectural plan. The dignity and beauty of the building are enhanced by the contrast of the lofty "skyscraper" buildings of the vicinity; and when

the structure is completed, the eye will turn with a sense of relief from the exaggerated perpendicular lines of the modern office building to the long, low perspective of this station, relieved at its mid-length by the lofty walls and roof of the waiting room. The exterior construction is of pink Milford granite, similar to the building stone of the Boston Public Library and the University Club in New York. This is a particularly effective structural stone, and its soft shades of color are decidedly pleasing to the eye.

VIEW OF THE NEW GRAND CENTRAL STATION FROM FORTY-SECOND STREET.

The main entrance to the station for foot passengers will be at the center of the Seventh Avenue façade and opposite the intersected end of Thirty-second Street. Once inside the building the passenger will find himself in a noble arcade, 45 feet in width and 225 feet in length. On either side will be shops where will be displayed wares suitable to the needs of the traveler. At the further end of the arcade the intending traveler will pass the entrance to two large restaurants, one to the left, the other to the right, and will then find himself at the head of a broad flight of stairs leading down to the floor of the general waiting room. This vast hall will be 103 feet in width, 277 feet in length, and will have a clear height from floor to ceiling of 150 feet. Within its spacious walls will be located ticket offices, parcel rooms, telegraph and telephone offices, and baggage checking windows, all so disposed that a passenger may proceed from one to the other in their logical order. Adjoining the general waiting room on the west will be two subsidiary waiting rooms, corresponding in their relation to the main hall to the two restaurants. Each waiting room will measure 58 x 100 feet. One of these is reserved for men, the other for women, and each will be provided with every convenience for comfort. The entrances for carriages will be by way of pavilions located at the corners of Thirty-first and Thirty-third Streets and Seventh Avenue. The carriages will descend on a slight gradient until they reach the level of the station proper. Entrance will be had by the Thirty-first Street incline, and the carriages will leave by the Thirty-third Street ascent as an exit.



The grand concourse on the upper floor will be 100 feet wide, 470 feet long, and 150 feet from floor to roof. To the right will be the entrance gates to the express tracks. On the lower floors will be waiting rooms, ticket booths, etc., and the loop and stub tracks for the local trains.

SECTIONAL VIEW OF THE NEW GRAND CENTRAL TERMINAL STATION.

To the east of the general waiting room is the main baggage room with its 450 feet of frontage. The baggage will be delivered and taken away by a special subway, 30 feet wide, which will extend under and along the entire length of Thirty-first Street and Seventh and Eighth avenues. From the baggage room trunks will be taken to the tracks below by motor trucks and elevators. Cab-stands will also occupy this level.

The passenger, after securing his ticket, checking his baggage, etc., passes through between the smaller waiting room entrances onto the great station concourse, an iron-and-steel-covered area over 100 feet wide, which extends across the entire width of the building. Crossing the concourse he will be confronted by a series of gates, bearing signs announcing the destination and time of departure of the trains on the various platforms below at the track level. The concourse and the adjacent areas are open to the tracks, and together they form a great courtyard 340 feet in width by 210 feet broad, roofed in by a lofty trainshed of iron and glass similar in design to the famous trainsheds of the new stations in Frankfort and Dresden, Germany. In addition to the entrances to the concourse from the waiting room, there are also direct approaches from Thirty-first Street, Thirty-third Street, and Eighth Avenue. Below the main concourse, and located between it and the tracks below, is a sub-concourse, 60 feet in width, which will be used for exit purposes only. From the sub-concourse staircases and inclines will lead to the streets and avenues and to future rapid transit stations under Seventh or Eighth Avenue. Direct connection may also be made, in due time, with the proposed subway station of the Hudson Companies' subway running up Sixth Avenue from the North River tunnels of that company. The northern side of the station, paralleling Thirty-third Street, will be assigned to the suburban service of the Long Island Railroad. The third level, which will be at a depth below the surface of the street corresponding to the height of an ordinary four-story building, will be entirely covered below the station building with twenty-one parallel tracks and their respective platforms. Within the station area, covering 28 acres of ground space, there will be 16 miles of tracks. A trackage area of this amount will afford ample facilities for the easy movement by electric power of the many hundreds of trains per day that will use this station. Through trains from the West, after discharging passengers, will proceed at once to Long Island City, where the main train yard and terminals will be located, thus leaving the station tracks clear of any idle equipment. In like manner, the westbound through trains, which will be made up at the Long Island City terminal, will pass through the station, stopping only to take up their quota of passengers. The suburban service of the Long Island Railroad will be operated on the "shuttle" plan. The planning of the station, with its numerous entrances and exits independent of each other, and separating the incoming from the outgoing throng, was worked out to facilitate, in greatest measure, the prompt and uninterrupted movement of the traffic. The exposure of the building on all four of its sides to main arteries of street traffic gives the plan a flexibility which is rarely obtainable and also insures easy connections by underground subways with the future extensions of the city's rapid transit system. The station will probably be opened for service early in 1910.

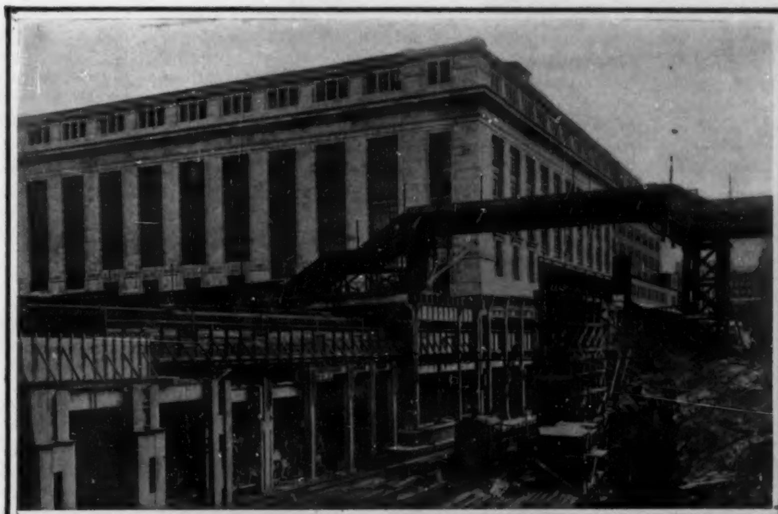
NEW GRAND CENTRAL TERMINAL STATION.

Of equal importance to the Pennsylvania terminal above described is the reconstruction of the terminal station of the New York Central & Hudson River Railroad Company at Forty-second Street, familiarly known as the Grand Central. Briefly summarized, this work includes the removal of the old train shed (which was done a few months ago); the pulling down of the present terminal and office building; a great enlargement of the present station yard, and its excavation to an average depth of about

40 feet below the old level, the work involving the removal of over 2,000,000 yards of material; the erection of new terminal buildings and offices on a greatly enlarged scale; and the electrification of this terminal and the main line of the road for thirty-five miles out from the city. Incidentally, this work has also involved the electrification of the main line of the New York, New Haven & Hartford Company, whose trains enter the Grand Central station, from Stamford, thirty-five miles distant, to the junction of that company's lines with the New York Central system, at Woodlawn.

The station building proper, together with the general offices of the company and the post office and express buildings, will cover the blocks lying between Vanderbilt and Lexington avenues from Forty-fifth to Forty-third Street, inclusive, and the block fronting on Forty-second Street between Vanderbilt Avenue and Depew Place. The main architectural features are governed strictly by the ground plan, the dominant architectural elements being determined in every case by the structural engineering necessities of the station. The southerly façade will stretch for 300 feet on Forty-second Street, and the westerly façade, including the broad approach on Forty-second Street, will reach for 680 feet on Vanderbilt Avenue. The building will extend 625 feet on Forty-fifth Street, 400 feet on Lexington Avenue, 275 feet on Forty-fourth Street, and 260 feet on Depew Place. The southerly half of the building incloses the station proper, this portion extending as far north as the northerly side of the great arched roof, seen in our sectional view. The northerly part of the building is given up to the offices of the company.

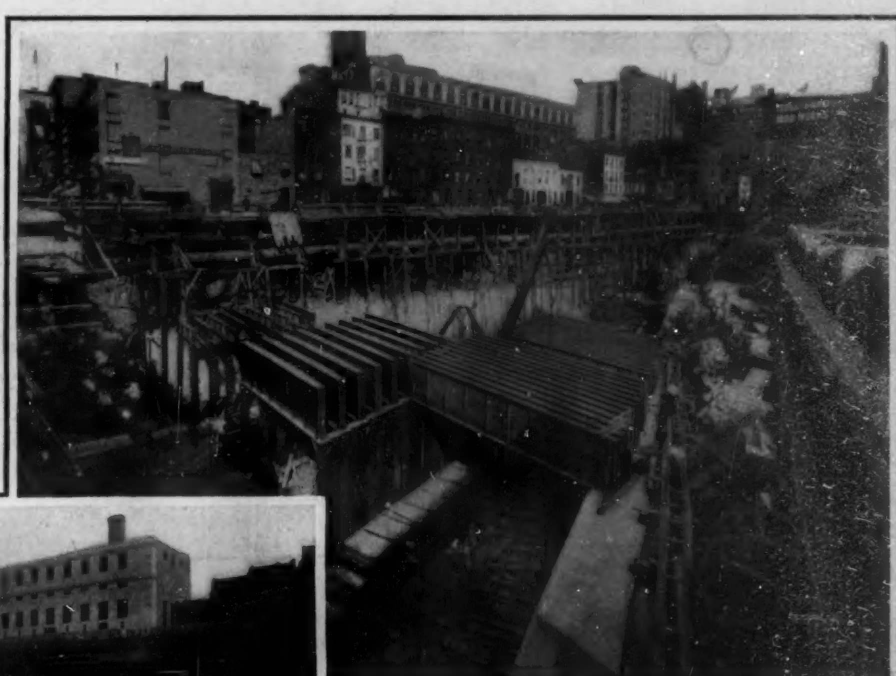
The imposing main entrance to the station on Forty-second Street is composed architecturally of three massive arches, each 33 feet wide and 60 feet in height. On entering, the passenger will find himself on a broad gallery, which runs around three sides of the grand concourse. From the gallery, passengers will descend by broad staircases to the floor of the grand concourse, which, by the way, is considerably the largest of its kind in the world. Its width is 160 feet, its length 470 feet, and the height from the floor to the top of the domed roof is 150 feet. The noble arched and domed roof of the concourse will extend entirely across the full width of the station building, a distance of 300 feet, or from Vanderbilt Avenue to Depew Place; but the concourse floor will be carried westerly under Vanderbilt Avenue for a distance of 170 feet. Back of the concourse, and located under the broad approach on Forty-second Street, will be the ticket booths and main waiting room, which will have twice the area of the present one. Surrounding it will be several retiring rooms, telephone and telegraph booths, and the various other conveniences of a modern station. Back of the waiting room will be a large restaurant. Across the northerly end of the concourse will extend the customary line of gates admitting to the express platforms. Beyond the gates will be located no less than thirty-four stub tracks, with broad platforms between them, the average width being about 16 feet, extra space being provided, in order to avoid the excessive crowding which is such a troublesome feature under existing conditions. Of these thirty-four tracks, the westerly eight or ten will be reserved preferably for incoming trains, and the arriving passenger, on passing through the gates onto the concourse, will find himself opposite a large cab stand, and with conveniences right at hand for securing his trunk and driving away with it with as little delay as possible. In addition to leaving directly by cab, he has the choice of four other means of exit from the station; for he may pass by a covered walk directly to the Subway, or by a 25-foot stairway to the concourse gallery and so to the street, or he can pass out



This view shows on the right the present level of the old station yard; on the left the lower and upper levels of the new yard, and the new Post Office building, whose architecture conforms to that of the new station building.

The completed portion of new yard. The new Post Office. Site of the train shed.

GENERAL VIEW OF THE NEW YORK CENTRAL YARD, SHOWING PRESENT CONDITION OF WORK.



VIEW OF THE SUBSTRUCTURE OF NEW PENNSYLVANIA TERMINAL STATION, SHOWING THE CONVERGENCE OF THE YARD TO THE TUNNELS LEADING TO LONG ISLAND.

VIEW OF PORTION OF THE HUGE EXCAVATION FOR THE PENNSYLVANIA TERMINAL, SHOWING BAGGAGE SUBWAYS.

to Madison Avenue and Forty-third Street by a covered subway, or crossing the concourse, he may leave by another covered subway to Lexington Avenue. It will be understood, of course, that the thirty-four tracks extend the full width of the concourse, the most easterly track abutting on Depew Place and the most westerly on Vanderbilt Avenue, and this, of course, necessitated some careful engineering work in supporting above these tracks the immense weight of the northerly half of the station building, containing the company's offices. Care has been taken to so arrange the supporting columns that none of them shall interfere with the passenger platforms.

The plans for the new station involved, as an absolute prerequisite to success, that the suburban travel should be entirely separated from the express; and it was considered that the best way to insure this was to place the suburban tracks below the express tracks and provide a suburban concourse, waiting rooms, and other conveniences on this lower level. Moreover, it was decided that, with a view to further separating the two classes of travel, separate entrances and exits should be provided, so that the suburban passengers could enter or leave the lower level from the street or the Subway without meeting the long-distance travel. Access to the suburban tracks and station is obtained by gradually depressing the two outside tracks in the entrance tunnel below Park Avenue until they reach the lower level. In the rush hours the suburban trains will pass into the station and around a loop which will extend beneath the restaurant on the express level, the trains passing out again without breaking bulk. Toward the close of the rush hours, alternate trains will discharge their passengers from the series of seven stub tracks, which occupy the train space within the loop and in front of the suburban concourse. Trains will be stored here and in the station yard until the evening rush hour, when they will be switched out into service again. Provision is made at the inner end of the loop for connection direct to the tracks of the Rapid Transit Subway below Fourth Avenue; and it is a fortunate circumstance that the Chief Engineer of the Subway, by moving the two tunnels below Park Avenue over toward the curb line, made provision for this connection with the New York Central system, although, at that time, the New York Central Company was not disposed to consider any such connection.

In conclusion, it should be mentioned that the capacity of the Park Avenue tunnel has been increased at least one hundred per cent by the great enlargement of the station yard. One of the most serious obstacles to a further increase in the number of passenger trains under existing conditions, is the fact that the storage yard for express trains is at present located at Mott Haven, and every express train that enters New York has to make the trip through the tunnel four times, twice in entering and leaving the station with passengers, and twice in making the round trip to the yard for cleaning purposes. With the enlarged area of yard provided in the new arrangement, the storage of express trains will take place at Forty-second Street, and the tunnel will be relieved proportionately. The excavation of the yard involves, as we have noted above, the removal of over 2,000,000 cubic yards of material. The express and local service will be separated, the former using the upper and the local the lower deck of the station. The upper level will be depressed some 15 feet below the present yard level, and Park Avenue and the various cross streets will be carried over the yard on steel viaducts.

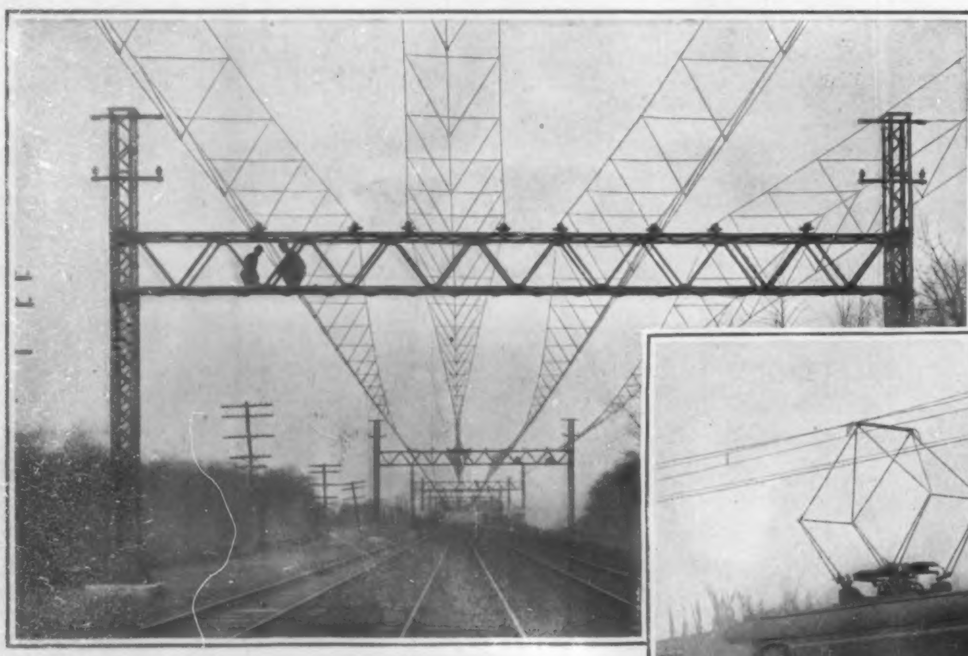
The New York Central lines are operated on the third-rail direct-current system. The third rail is carried on brackets supported on extensions of the ties, the contact rail being under-hung, and the shoes on the electric locomotive bearing against the under side of the rail, which is protected by wooden sheathing on the top and sides of the rail. This sheathing has been found to afford not only a most excellent safeguard to employees and foot passengers, but has proved to be an excellent construction for preventing clogging of the rail by snow and ice in the winter time. The long distance trains are operated by electric locomotives of about 2,300 rated horsepower which weigh 100 tons. They have proved to be capable of handling the heaviest express trains of the system with a considerable margin of power to spare. The local trains, operated by the multiple-unit system, have shown in actual service a great advance on the old steam-operated trains on every point of comparison. Current is generated in two identical power stations, one at Yonkers, and the other at Port Morris. When the complete plant has been installed each station will have a capacity of 40,000 horsepower, and each has sufficient capacity to operate the whole system. The plant was built in duplicate, with a view to having a complete reserve plant at command in case of breakdowns. The whole of the equipment of New York Central lines was built by the General Electric Company; and they are to be congratulated on the fact that from the very inception of the service it has been operated with a remarkable freedom from breakdowns or interruptions of any kind.

The equipment of the four-track road of the New York, New Haven & Hartford Railroad Company from Stamford to Woodlawn possesses unusual interest from the fact that this represents the first attempt to operate a heavy trunk railroad by the alternating current. Among the theoretical advantages of this system over the direct-current system, is the fact that sub-stations are done away with, and their heavy expenses due to initial cost and the maintenance of skilled staffs of operators are saved. The current is generated at a power station located at Cos Cob, and is delivered to the overhead line at 11,000 volts. Each locomotive carries its own transformers, of which there are two to each locomotive. This adds greatly to the weight, which reaches the high figure of 95 tons for a rated horse-power of about 1,000. An interesting feature of these machines is that they are arranged to take either single-phase current from the overhead lines or direct current from the third rail. The overhead

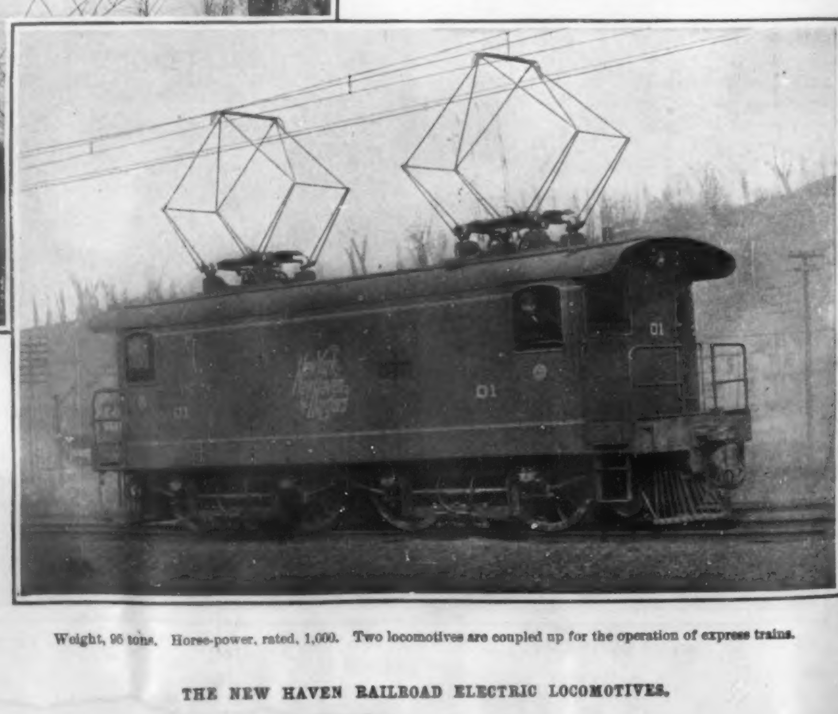
(Continued on page 417.)

The locomotive, which weighs 100 tons, can develop a maximum of over 3,000 horse-power.

START OF THE FIRST ELECTRIC TRAIN FROM THE NEW YORK CENTRAL STATION.



THE OVERHEAD LINE OF THE NEW YORK, NEW HAVEN AND HARTFORD RAILROAD, WHICH CARRIES CURRENT AT 11,000 VOLTS.



Weight, 95 tons. Horse-power, rated, 1,000. Two locomotives are coupled up for the operation of express trains.

THE NEW HAVEN RAILROAD ELECTRIC LOCOMOTIVES.

FREIGHT DISTRIBUTION BY SUBWAY

The city of New York contains within its cramped area 5 per cent of the nation's population, produces 11 per cent of the manufactured products, and serves as an outlet for nearly one-half of the country's foreign commerce. Stated more in detail, this means that the imports and exports alone, which in 1907 passed through the city, amounted to 13,000,000 tons, valued at $1,600,000,000. According to testimony given before the New York Commerce Commission in 1900, the annual tonnage of all kinds exceeds 100,000,000. One would suppose that for the handling of this huge amount of freight the most efficient and splendidly equipped transportation system would be found in the metropolis of the western hemisphere. As a matter of fact, probably no large city of the world handles its freight so clumsily and expensively as this same metropolis. At present the New York Central and Hudson River Railroad is the only line that has direct rail access to Manhattan Island, and there have been repeated attempts in recent years to abolish the terminals of that road within the city and to compel it to devise other means of handling the 5,000,000 tons of freight that now enter New York at Spuyten Duyvil. Because the New York Commerce Commission and the New York Chamber of Commerce have laid down a policy which forbids an increased use of waterfront space, any attempt to utilize the waters around New York instead of the railway mentioned would be frustrated.

Freight is now brought to New York city by the transatlantic and coast steamship lines, by several railways which terminate on the New Jersey bank of the Hudson River, by the New York Central freight line with yards lying within the city and in the Borough of the Bronx.

The steamship lines loaded and unloaded 9,400,000 tons of freight on New York or New Jersey docks in 1906-1907. A portion landed in New Jersey and intended for New York had to be brought across the Hudson River and carted off; another portion, landed in New York and intended for other cities, was unloaded and ferried across the Hudson to the railway terminals on the Jersey shore; and a third portion was carted to the New York Central freight yards for further shipment. The reverse process was carried out when goods were shipped out of the city by steamer.

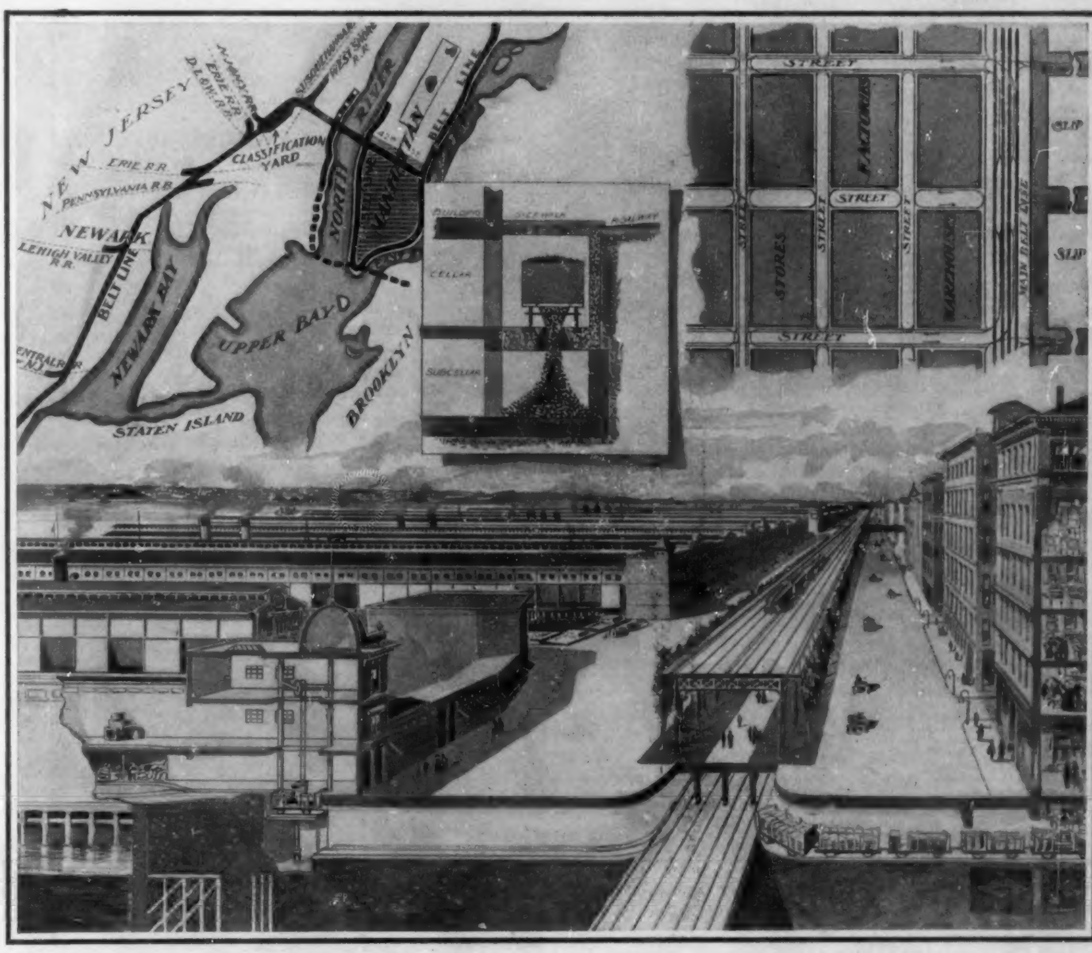
The freight which arrives at the railway terminals on the Jersey and Long Island shores and which is intended for New York must be brought across the river in car-ferryboats and eventually distributed by drays.

All the freight which is brought to the city by the New York Central lines terminating in the Borough of Manhattan is cumbrously and expensively conveyed in trucks. There is also a large amount of merchandise which is similarly carted to the steamship lines and to the New York Central freight yards for shipment to other points. All this unloading, carting, and loading again has resulted in packing the business streets of New York with a dense mass of vehicles, each crawling to its destination as best it may in thoroughfares laid out for five-story buildings and gorged with the outpourings of twenty-story structures. Anyone who has ever seen West Street, South Street, and Broadway on a week day can realize that the conditions pictured are not exaggerated.

The cost of handling the 23,200,000 tons of freight brought into and shipped out of New York city by railways and steamships is enormous. With the exception of that portion of the New York Central's tonnage which is drayed to and from its terminals, all railroad freight requires lighterage and break of bulk at the waterfront. The cost of lighterage varies from 83 to 88 cents per ton. The cost of cartage on city streets varies from 60 cents to $1.25 a ton, depending on the haul and the character of the freight. It is not astonishing that in a single year the merchants of the city of New York pay $33,570,000 for hauling 23,200,000 tons of freight through the streets.

With the available water frontage on the commercial portion of Manhattan Island incapable of enlargement, and with an urgent demand by the water carriers for more room, some method of land cartage must obviously be devised that will decrease rather than increase the need for railroad space on the waterfront. Mr. William J. Wilgus, an engineer whose wide experience in adapting the New York Central's passenger terminals to the ever-growing needs of the city has admirably equipped him for the task, has made a painstaking study of this peculiar problem, and offered to the Public Service Commission, on behalf of the Amsterdam Corporation, a solution which apparently secures the benefits of rail connection not only with the New York Central's freight terminals, but also with all the other railroads now terminating on the New Jersey side of the Hudson River and in the Borough of the Bronx. Moreover, he has devised an improved method of distributing freight, whereby the time for delivery is lessened, the present high terminal charges reduced, and the harbor and the city streets relieved of congestion. Briefly stated, Mr. Wilgus proposes the construction of a system of cartage subways which will tap both sides of the principal business streets below Forty-second Street, and which will be surrounded by a high-speed belt line connected with railroads terminating on the west side of the North River, with the Sixtieth Street yard of the New York Central on Manhattan Island, and with the railroad terminals in the Bronx. Provision is also made for tunnel extensions to Long Island City and Brooklyn and along the Jersey waterfront. The transshipment of freight is to be made at remote points where space is less congested and costly than along the waterfront. The subways are to be of such dimensions that they will be able to handle at least 90 per cent of the commerce of lower Manhattan Island, and that, moreover, with but one change of bulk at points remote from the congested portions of the city. A special type of standard-gage car is to be used for steep grades, curves, and for elevators in the shipping and commercial districts. The type of car to be used is to have sufficient capacity to accommodate the largest package of merchandise and still economize space, so as to permit the delivery of cars directly to the water carrier, merchant, and manufacturer, free from contact with the surface of the city streets and removed from the expenses, uncertainties, and delays of harbor navigation. Such a car can run on the tracks of connecting trunk lines, over which it can be sent to points at a considerable distance from New York. Elaborate as such a system of subways must necessarily be, Mr. Wilgus claims that it will not prevent the construction of future subways nor interfere seriously with sewers. The streets will be cleared of the boxes and bales that obstruct the sidewalks. As the accompanying illustration shows, the relief of the marginal way from trucking will render the thoroughfare along the waterfront available for an elevated passenger railway and for light vehicular traffic between the business and residential sections of the island.

Mr. Wilgus places the approximate cost of such a system between a minimum of $80,000,000 and a maximum of $100,000,000. If the plan is carried out, he believes that it will solve the West Side problem; that it will relieve the streets of their present dense traffic; that it will render Manhattan Island directly accessible to all shippers who use the railroads; and that it will release docks and piers from railroad uses and permit the expansion of legitimate water-carrier traffic.



New York spent in the year 1906 to 1907 about $37,000,000 for carting freight through its streets to and from steamship docks and railroad terminals. This system of subterranean cartage subways, with a railway belt tunnel extending around the city and communicating with the steamship docks and with the railway terminals lying both within the city and along the New Jersey shore, is designed to handle 90 per cent of this freight at a small cost, so as to leave the streets clear and allow the waterfront to be used more or less exclusively for legitimate purposes.

PROPOSED SYSTEM OF FREIGHT SUBWAYS FOR NEW YORK CITY.

The present congestion is causing a gradual decrease of the city's rate of growth, and we are undoubtedly confronted with the necessity of improving transportation facilities if New York is to hold its pre-eminent position. In 1899 the foreign commerce of the port of New York was 50 per cent of the total for the United States; last year it was but 45 per cent. Similarly, the value of production has fallen from 12 to 11 per cent of the national total. From these data it must be concluded that any improved method of freight transit is worthy of serious consideration, particularly since the first requirement of this great port is ample space for the accommodation of water carriers in close relation to railroads, warehouses, and the active business district of the city.

The Abrasive-Resisting Qualities of Conveyer Belts.—Strips of seven materials, mounted on a board and subjected to the uniform action of a sand blast for 45 minutes, show the following relative abrasive-resisting qualities, rubber belting being taken as the standard: Rubber belt, 1; rolled steel bar, 0.66; cast iron, 0.28; balata belt, including gum cover, 0.2; woven cotton belt, high grade, 0.16; stitched duck, high grade, 0.13; woven cotton belt, low grade, 0.06 to 0.11.—T. A. Bennett, in the discussion of papers on Conveying of Materials, read at the Detroit meeting of the A. S. M. E.

THE CATSKILL WATER SUPPLY.

(Continued from page 396.)

in height and 17½ feet wide, which will be built partly by the cut-and-cover method and partly in tunnel. It will extend to the westerly bank of the Hudson River, which will be reached at a point between Cornwall and West Point. Originally it was the intention to carry the aqueduct below the Hudson River at New Hamburg; but the preliminary borings at this and other sites proved that it would be difficult to find a rock sufficiently clean from fissures and other imperfections. An examination of various sites by geologists led to the ultimate selection of the crossing near Cornwall, where it was believed that a thoroughly sound and suitable rock would be found at a depth not too prohibitive. The aqueduct passes through the mountains and reaches the westerly shore of the Hudson River at an elevation of 400 feet above tide level. Here a vertical shaft will be sunk to a depth of probably not less than 700 feet below the river surface, or 1,100 feet below the level of the aqueduct. In the bottom of the shaft a tunnel will be driven horizontally beneath the river to connect with another vertical shaft of practically equal depth on the easterly bank of the river. From this point it will be constructed through the mountains until it reaches the new Croton reservoir. Here connections will be made to enable the water to be drawn directly from the Ashokan reservoir into the Croton reservoir, with a view to augmenting the Croton supply until such time as the aqueduct from Ashokan to New York city shall have been completed.

From the Croton reservoir the aqueduct will be continued south to Kensico reservoir, which will be enlarged to include Rye Pond and will form an auxiliary storage reservoir at an elevation of 355 feet above mean tide, capable of containing 25 billion gallons, or sufficient to supply the city at the rate of 500 million gallons per day for a period of fifty days. About four miles south of Kensico, at Scarsdale, there will be built a large filtering plant, and at Hillview, six miles to the south of this, will be another storage reservoir. With these two auxiliaries or emergency reservoirs provided, the city will be secured against any sudden interruption of its supply through failure of the 69 miles of aqueduct lying to the north of them. By the construction of a tunnel of 200 million gallons daily capacity below the East River, Brooklyn and Staten Island will be provided with a supply of 100 million gallons daily, and this aqueduct will terminate in a large reservoir to be constructed in Forest Park. From the point where this tunnel reaches the shores of Long Island, a line of 20 million gallons capacity will be built through Brooklyn and below the Narrows for the supply of Staten Island.

TUNNELS AND SUBWAYS.

(Continued from page 405.)

the shield it was customary to allow the silt, etc., to pass into the interior of the tunnel as the shield was advanced, and take it away in cars. The Hudson Companies' engineers decided, however, to try the plan of pushing the shield ahead by displacement; that is to say, they closed the doors in the front face of the shield, and tried the experiment of pushing the shield bodily through the silt, causing the latter to flow over and around the tube by displacement. The plan succeeded beyond expectations, and the later work was all done by this method.

One of our illustrations shows the way in which the engineers overcame a serious obstacle, in the shape of a ledge of rock, which projected from the river bottom and covered the lower half of the path through which the tunnel was to be driven. To meet the emergency, a heavy iron working roof was built in front of the shield, and under this the workmen were enabled to set up their


COMPANION

drills and blast out the obstruction. At the point of connection of the tunnel tubes with the Subway tubes running along the Jersey shore, it became necessary to work out the difficult problem of operating the trains to their various destinations without incurring dangerous crossovers on tracks running in opposite directions. The difficulty was solved by running the pairs of tunnels at such junction one above the other, and arranging the crossovers within huge double-deck caissons of the type shown in the illustration of this work. These caissons, which are truly mammoth affairs, 45 feet wide, 45 feet deep, and 106½ feet long, bigger than anything of the kind heretofore constructed, are built of reinforced concrete. The walls were first sunk to the desired depth, the necessary openings being left for connection with the tunnel tubes. Then the floor, the intermediate deck, and the roof were built, leaving the huge box-like structure ready for connection with the tubes and the laying of the tracks. The construction is clearly shown in our sectional view of the same.

The plans of the Pennsylvania Railroad Company for establishing a large terminal station for their system in the center of Manhattan Island, and connecting it with their trunk line to the West and the extensive system of roads of the Long Island Railroad Company to the East, has involved the construction of subaqueous tunnels of even greater importance than those of the Hudson Companies above referred to. Access to Manhattan Island is obtained by two single-track tubes, and to Long Island by four such tubes. As compared with the Hudson Companies' tunnels, those of the Pennsylvania Company are much larger, heavier, and more expensive to build. It was considered at the very outset that special strength and solidity would be necessary to safely carry the heavy trans-continental trains of Pullman cars. Accordingly, the tubes were made of an external diameter of 23 feet; and the segments were cast with an unusually heavy shell and deep flanges amply provided with bracing. The interior of the tube is lined with no less than two feet of concrete; and, in addition to this, the concrete is carried up parallel with the sides of the cars to the height of the window sills, where a broad shelf, wide enough to permit the passengers to walk in case of a breakdown, is provided. This shelf is formed integrally with the concrete lining of the tunnel. In the preliminary investigation of the problem, it was considered possible that the impact of the heavy trains upon the floor of the tunnel would tend to cause some settlement of the tubes in the silt in which they had

been driven; and, as a provision against this, the original plans provided for sinking hollow cast-iron piles through the floor of the tunnel to bedrock, and laying the tracks upon a system of longitudinal girders within the tunnel, which would serve to transfer the trainloads directly to the piles, and so relieve the tubes themselves from all stresses due to live loads. These piles were to be 27 inches in outside diameter, with a shell 1½ inches in thickness. After the tubes had been driven, the satisfactory behavior of the Hudson Companies' tubes, which were built without any pile supports and have failed to show any settlement after many months of operation, convinced the engineers that the Pennsylvania tubes would be sufficiently stable without the supporting piles; and, consequently, this feature has been omitted. The tubes were driven by the shield method, and the work was pushed through without developing any problems of a serious or unusual character. The same may be said of the building of the tunnels across Manhattan Island, where the work consisted for the most part of straight rock excavation. With a view to accommodating the heavy future increase in suburban traffic to Long Island, the company determined to build four separate tubes beneath the East River. Because of the difficult character of the material encountered, the work on these tunnels has been somewhat protracted, many blowouts having developed, necessitating the construction of a false bottom to the river above the heading of the tubes by dumping in many thousand cubic yards of material from scows. All obstacles, however, have been overcome, and the whole of this vast tunnel system will have been completed before another twelvemonth has gone by. The total length of the run in tunnel from the portal in Jersey City to the portal on Long Island is 5.3 miles. The total length of single-track tube tunnels under the two rivers is 6.8 miles, and the total length of single-track tunnel under the land is also 6.8 miles. The total length of track in tunnels exclusive of the yard tracks and the station will be 16½ miles.

Contemporaneously with the execution of the above work, the financial interests which are responsible for the operation of New York city's subways were engaged in constructing a twin-tube tunnel below Forty-second Street and the East River from the Grand Central Station, Manhattan, to Long Island City. The tubes are similar in dimensions and general construction to those which form the connecting link at the Battery between the Manhattan and Brooklyn Subway systems. The tunnel was built under an old franchise granted many years ago, and it has been offered for purchase by the city at a price of $7,000,000.

NEW GRAND CENTRAL TERMINAL STATION.

(*Continued from page 412.*)

trolley system consists, for each track, of two steel messenger wires below which is carried, by means of triangles of steel tubing, the ⅜-inch copper trolley wire. In the early days of the operation of the system, difficulties developed, due to the hammering of the collector shoes as they passed the points of suspension of the wire at the apex of the triangles. This was cleverly overcome by suspending a second wire below the first by means of clips attached to the upper wire midway between its points of suspension from the triangle. The arrangement has provided a system which combines great stiffness with uniform flexibility of the trolley wires; and the troubles of sparking, wear, and breakage have been practically eliminated. The electric locomotives, which because of their short wheel base were found to sway heavily at high speed, have later been provided with end trucks of ingenious design, which have completely eliminated the trouble, and rendered these locomotives as steady in their running as a Pullman car. The whole of this work was done by the

Westinghouse Company; and both they and the New Haven Railroad Company are to be congratulated on having overcome, in spite of many initial discouragements, the inevitable difficulties attending the execution of pioneer work, on such a vast scale and under the stress of traffic of one of the busiest four-track systems in the world.

In closing it should be mentioned that the results of operation of these two systems are claimed by the companies to have been highly satisfactory. The number of train movements in the yard has been greatly reduced, the Park Avenue tunnel has been robbed of its terrors, and even to-day, while the work of excavating the yard is in progress, the trains are being operated at this terminal with a regularity and dispatch which has never been surpassed in the early history of the road.

INDEX OF INVENTIONS

For which Letters Patent of the United States were Issued for the Week Ending November 24, 1908.

AND EACH BEARING THAT DATE

[See note at end of list about copies of these patents.]

Agitating and aerating apparatus, L. C. Trent 905,025
Air brake system angle cock, W. Bernerd 904,502
Amusement device, Hamilton & Meilre 904,953
Animal trap, W. Sebelin 905,006
Armor exploding projectile, A. Wratzke 905,042
Ash handling apparatus, C. G. Armstrong 904,916
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Automobile transmission gear and casing, E. J. Gulick 904,774
Automobile transmission mechanism, M. O. Reeves 904,723
Automobiles and like vehicles, generation, control, and transmission of electric energy, particularly for use on, A. H. Midgley 904,794
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Electric machines, current collecting apparatus for dynamo, J. E. Noeggerath........ 904,801
Electric machine voltage regulator, dynamo, G. S. Neeley........ 904,887
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Electric welding, L. S. Lachman, 904,540, 904,881, 904,882
Electric welding rotary converter, A. M. Hoffman........ 904,782
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Engine starting mechanism, internal combustion, Holden & Elphinstone........ 904,616
Engines, carbureter for internal combustion, G. Enrico........ 904,955
Engines, device for reversing the direction of rotation of internal combustion, L. Le Pontois........ 904,624, 904,625
Engines, means for connecting and disconnecting, S. S. Smith........ 905,011
Envelop, W. J. Bernthold........ 904,750, 904,751
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Fabric. See Wire bed bottom fabric.
Fabric, textile, G. P. Schlemmer........ 905,106
Fabrics, manufacture of multicolored, M. Bohler........ 904,752
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Shoe tree or form, S. M. Hamblin	904,775
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COMPLETE LISTS of manufacturers in all lines supplied at short notice at moderate rates. Small and special lists compiled to order at various prices. Estimates should be obtained in advance. Address Munn & Co., List Department, Box 773, New York.

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Inquiry No. 8875.—For makers of chain, also forged iron hinges.

Inquiry No. 8876.—Wanted to buy wood rolls 1½ inches in diameter and 8 inches long, with iron journals ⅜ inch in diameter, suitable for wringers.

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Tires, composition for preventing leakage of air through puncture in pneumatic, Rogers & Myers 904,895
Tobacco pipe, J. Monson 904,633
Tobacco stripper, T. P. Ford 904,770
Tobacco substitute, masticable, C. Ellis.... 904,521
Tool case, hand, O. Madeira 904,545
Tool handle wedge, J. W. Hair 905,069
Tool holder, C. E. Bown 904,504
Tool holder, H. Vogel 904,579
Tool, impact, C. B. Richards ....904,724 to 904,726
Tool, pneumatic impact, G. L. Badger...... 904,827
Tool, punching, T. McGrath 904,714
Tool, staking, F. R. Cunningham.......... 904,847
Tool, stone working, Greve & Richards.... 904,692
Tooth, artificial, F. D. Case.......... 904,601
Toy, J. Lexow 905,085
Train order signal, L. H. Van Zandt....... 905,120
Transfer, J. W. Hents 904,778
Transom operator, G. H. Lawrence........ 904,973
Trap, M. Engstrom 904,608
Trap, B. A. Martinson 904,706
Trench digger carrier, F. R. Batchelder, 904,596, 904,597
Trolley and telegraph pole, combination, J. Hackett 904,952
Trolley wheels from jumping, device to prevent, W. O. Lane 904,541
Truck, car, R. H. Benners 904,670
Truck, transfer, G. P. Baldwin 904,919
Tub trap, rinse, W. L. Koenig 904,539
Turn table, piano, Sullivan & Ring........ 905,018
Twine holder, J. M. & R. E. Pinegar...... 904,722
Typewriting machine, E. E. Barney....... 904,669
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Typewriting machine, H. W. Merritt...... 904,708
Typewriting machine, H. L. Wagner...... 904,737
Typewriting machine, J. Oppenheim....... 904,803
Typewriting machine, H. C. Ferguson, 904,857 to 904,859
Typewriting machine, L. A. McKeever..... 904,982
Typewriting machine, H. H. Steele........ 905,013
Typewriting machine, J. C. McLaughlin.... 905,091
Umbrella repairing device, E. H. Stoddard.. 905,016
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Valve, emergency, O. Penn.......... 904,985
Valve for hydrocarbon lighting systems, M. W. Pitner 904,987
Valve, piston, Christman & Johnson........ 904,839
Valve stuffing box, engine, J. J. MacMulkin 904,790
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Vehicle gear, J. D. Weekes 904,822
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Wall, partition, W. J. Perkins.......... 905,096
Washing machine tubs, wringer box or tray for, W. H. Voss 905,028
Watch, stem winding and setting, W. E. Porter 904,989
Water closet bowl, C. H. Rollins 904,896
Water elevator, A. Haas 904,951
Water heater, L. D. Lovekin 904,627
Water motor, J. P. & H. P. Shevlin.......... 904,567
Water supply system, J. T. Lemon..........904,883
Watermobile, P. McDermott 904,713
Weed cutter and puller, combined, H. S. Wimmer 905,039
Weighing machine, T. S. B. Parnall.......... 904,718
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Wheel grinder, band, P. A. Canes.......... 904,509
Wheel guard or fender, C. T. Moss 904,980
Wheels, antifriction thrust bearing for, W. J. Trevessick 904,575
Whip snap fastener, P. E. Gold 904,610
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Wire bracket or holder and insulator, I. L. Edwards 904,945
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Wire fastener, A. W. Burbury 904,506
Wire stretcher, W. C. Richardson 904,997
Wire stretcher and wagon jack, combined, E. G. Boyes 905,052
Wiredrawing block, H. B. Humphrey...... 905,077
Wiredrawing machine, C. A. Carlson...... 904,836
Wood, apparatus for use in treating, S. S. Williams 904,589
Wrench, T. W. Harber 904,954
Wrench, J. G. Swallow 905,116
Wrench and tool holder, J. D. Heck........ 905,070
Yoke center, neck, H. H. Bromley.......... 904,934

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Boots and shoes, leather, United Shoe Machinery Co. .... 71,456 to 71,458

Boots, shoes, and slippers, F. Valdes & Co.	71,459
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Cantaloups, H. H. Hawkins	71,377
Carbon paper and typewriter ribbons, Mittag & Volger	71,447
Cement, aluminium pipe, A. Wilhelm Co.	71,463
Cigarettes, cigars, and tobacco, Maspero Freres	71,493
Cigars, P. Alvarez & Ca.	71,494
Cigars, cheroots, and cigarettes, Cayey-Caguas Tobacco Co.	71,490
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Coffee, blended, R. C. Williams & Co.	71,418
Collars, Hall, Hartwell & Co.	71,442, 71,443
Cotton piece goods, printed, Neuss, Hesslein & Co.	71,452, 71,453
Cutlery and tools, certain, Marshall-Wells Hardware Co.	71,387
Cutlery, certain, Stephen Richard Co.	71,415
Dental cream, Colgate & Co.	71,432
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Dyspepsia remedies, mother Seigel's Syrup Co.	71,448
Earthenware, porcelain, majolica, or clay articles, Wachtersbacher Steingutfabrik.	71,487
Foods, certain, Kahn-Beck Co.	71,382
Foods, certain, Richardson & Robbins Co.	71,412
Fruits and vegetables, canned, H. K. Fooks & Co.	71,376
Fruits, preserved, A. A. Kearns	71,383
Grease, axle, Belknap Hardware and Manufacturing Co.	71,424
Gum, chewing, C. H. Stewart	71,416
Hammers, trip, L. Mayer	71,391
Hats and caps of cloth, wool, felt, fur, and straw, Keith Brothers & Co.	71,445
Hats, felt, Fay-Gorman Co.	71,437
Hats, straw, G. George	71,440
Headlights, R. E. Dietz Co.	71,477
Hose, fabric, Eureka Fire Hose Manufacturing Co.	71,467
Hosiery, A. B. Andrews Co.	71,419 to 71,421
Hosiery, Bell Hosiery Co.	71,425
Hosiery, Burson Knitting Co.	71,429, 71,430
Hosiery, Davis Hosiery Mills	71,433
Knives and steels, butchers', F. Dick	71,573
Lamps, gas burning vehicle, R. E. Deitz Co.	71,478, 71,480
Lamps, oil burning, R. E. Dietz Co.	71,479
Laxative medicines, Wm. H. Clark	71,431
Leather and fabric gloves, Ben Strauss Co.	71,427
Liquor known as "Mezcal Tequila," Mezcal Tequila Distillery Co.	71,393
Locks and padlocks, door, Hibbard, Spencer, Bartlett & Co.	71,470
Matches, safety, J. A. Hunt	71,471, 71,472
Medicated salt for feeding to animals, B. R. Bonney	71,428
Medicines, certain, Dr. Bob Medical Co.	71,434
Metal articles, certain, Marshall-Wells Hardware Co.	71,389
Metal, babbitt, G. E. Sovereign	71,496
Milk, condensed, Mohawk Condensed Milk Co.	71,394
Non-intoxicating tonic made from malt and hops, R. L. Ihlenburg	71,378
Oil, olive, G. Ehrat	71,374
Oysters, canned, A. Booth & Co.	71,364
Pails, sheet metal, S. W. Milligan	71,475
Painters' materials, certain, A. Wilhelm Co.	71,365 to 71,367
Pants, men's and youths', Sweet, Orr & Co.	71,454
Paper bags, Eagle Paper Co.	71,466
Paper, tarred and roofing felt, building and roofing, Maurice O'Meara Co.	71,474
Pen and pencil or lead holder, combined, F. R. Wells	71,461
Pens, fountain, Mabie, Todd & Co.	71,446
Pencils, lead and colored, E. Faber	71,436
Perspiration absorbent, A. H. Hipple	71,444
Photographic developers and accelerators, H. S. Wellcome	71,460
Pills, laxative, Mother Seigel's Syrup Co.	71,449
Prints, certain, E. G. Soltmann	71,414
Pumps, lubricator, Phenix Lubricator Co.	71,397
Razor strops, R. W. Sunasack Co.	71,411
Remedy for diseases of the generative organs, Arent Bros. Medical Co.	71,422
Remedy for rheumatism, A. O. Fraley	71,439
Remedy for venereal diseases, Floyd Bros.	71,438
Rubber roofing, Seinscheimer Paper Co.	71,481
Rubber roofing, Hibbard, Spencer, Bartlett & Co.	71,649
Salmon, canned, A. Booth and Co.	71,488
Saws and machine knives, Simonds Manufacturing Co.	71,413
Screen like sections, certain hinged, E. O. Grover	71,468
Sheets and pillow cases, H. W. Baker Linen Co.	71,441
Sheets and sheeting, waterproof, E. A. Armstrong	71,423
Shells, loaded, Union Metallic Cartridge Co.	71,483 to 71,486
Silks and cotton dress goods, broad, Rogers & Thompson	71,497
Silver plated knives, forks, and spoons, Marshall-Wells Hardware Co.	71,473
Soap, laundry, Procter & Gamble Co.	71,398 to 71,410
Soap powder used for cleansing purposes, Larkin Co.	71,384
Solder, W. H. Finfrock	71,491
Sporting goods, certain, Marshall-Wells Hardware Co.	71,390
Squares, dividers, and levels, Marshall-Wells Hardware Co.	71,388
Suits, pants, and overalls, men's, Woods Manufacturing Co.	71,462
Suspenders, neckties, and scarfs, Tootle Campbell Dry Goods Co.	71,455
Syrup and molasses, compound of refiners', Pacific Coast Syrup Co.	71,395
Tea, C. W. Antrim & Sons	71,371
Teas and coffees, W. McMurray	71,392
Toffee, Mackintosh's Toffee Co.	71,385
Toy whistles, J. F. Perey	71,396
Wagon and other vehicle springs, Indianapolis Bolster Spring Co.	71,379
Washing powder, naphtha, American Commercial Co.	71,369
Waste, J. Milton Hagy Waste Works	71,380
Whisky, straight bourbon, Rugby Distillery Co.	71,495
Whisky, straight rye, American Wine & Spirit Co.	71,489

LABELS.

"Anti-Dirt," for a scouring preparation, Anti-Dirt Co.	14,514
"Excellent Medicated Egg and Poultry Tonic," for egg and poultry food, M. N. Risser	14,513
"Farrell's Wedding Breakfast Brand Table Syrup," for a compound of corn syrup, cane syrup, and flavoring, Farrell & Co.	14,512
"Health Beer," for beer, Milwaukee-Waukesha Brewing Co.	14,511

PRINTS.

"Made to Eat Not to Keep," for candies, Huyler's	2,389
"Mosaic Back, Columbia Playing Cards," for playing cards, United States Playing Card Co.	2,391
"Purekind Salt Water Taffy," for salt water taffy, Atlantic City Candy Co.	2,390
"The Girl Question is Easily Solved," for candy, Huyler's	2,388

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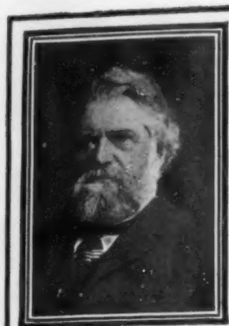
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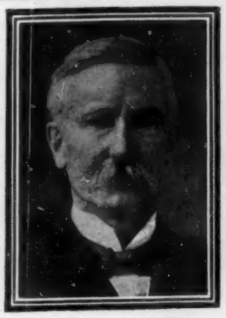
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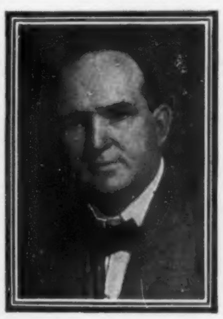
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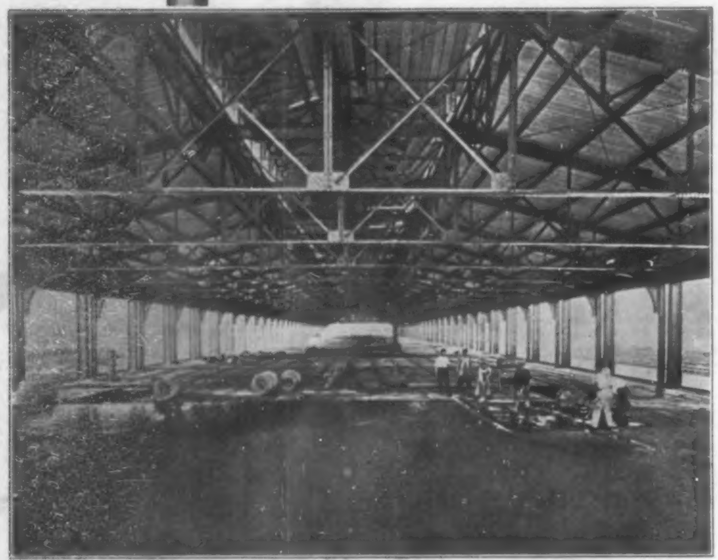

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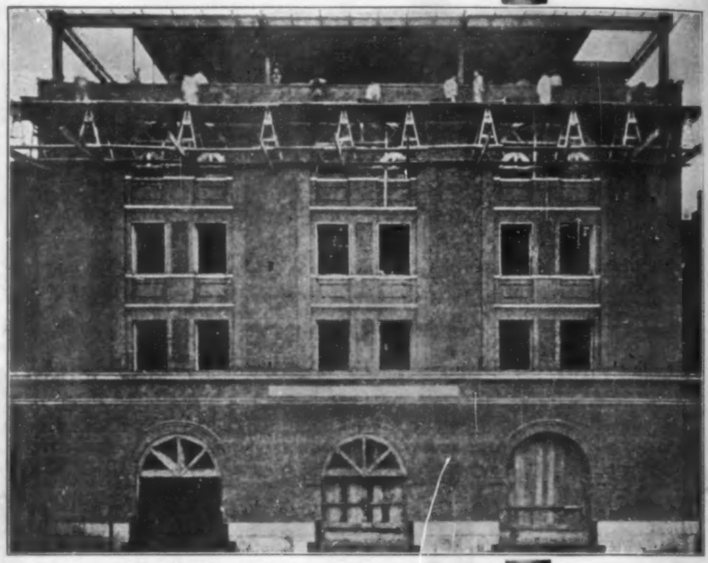
This pier will be occupied by the Cunard Steamship Company. Illustration shows method of securing Continuous Reinforcing across the entire building. The safest, surest and easiest way to make a reinforced floor foolproof is to use the continuous Bond of Clinton Electrically Welded Wire as a Reinforcing.



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